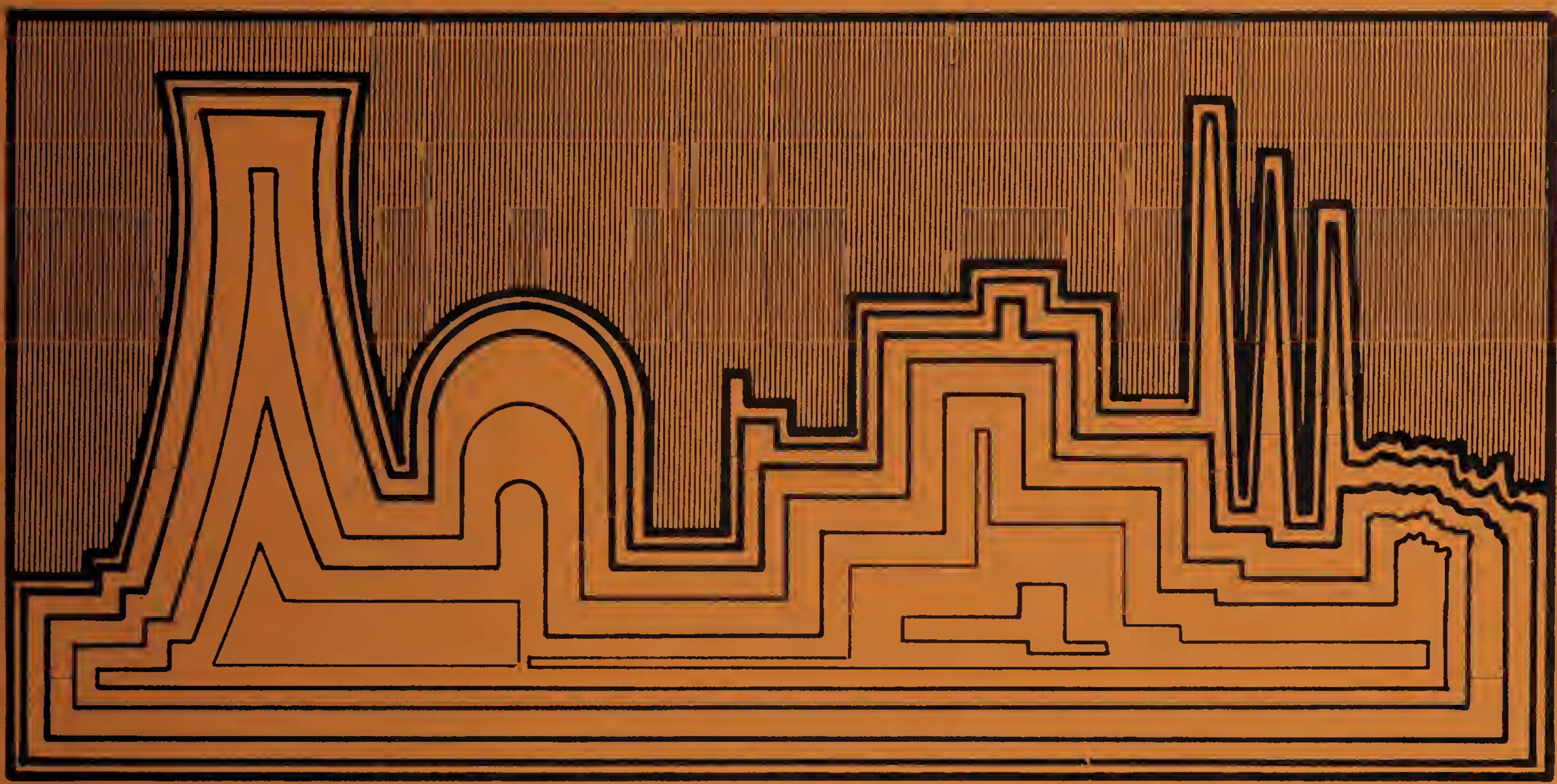
OHIO RIVER BASIN ENERGY STUDY

PRELIMINARY REPORT



WORKING DRAFT

MINI - TECHNOLOGY ASSESSMENTS OF FOUR ENERGY – DEMAND SCENARIOS TO THE YEAR 2000

UNIVERSITY OF ILLINOIS TEAM

MARCH 1977

OHIO RIVER BASIN ENERGY STUDY

PRELIMINARY REPORT

MINI-TECHNOLOGY ASSESSMENT OF FOUR ENERGY-DEMAND SCENARIOS TO THE YEAR 2000

(The Bureau of Mines Scenarios with 80% Coal-20% Nuclear and 50% Coal-50% Nuclear Fuel Mixes and the Ford Tech Fix Scenarios with 100% Coal or 100% Nuclear Increments)

UNIVERSITY OF ILLINOIS TEAM

March 1977

WORKING DRAFT

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

PREFACE

This is the second preliminary report to be prepared by the University of Illinois mini-assessment team for Phase I of the Ohio River Basin Energy Study. The study is being conducted under Contract No. R804821-01 for the Office of Energy, Minerals and Industry (OEMI), Office of Research and Development, U. S. Enfironmental Protection Agency, as part of its Integrated Assessment Program (IAP). During Phase I, the research teams are reviewing existing and potential energy conversion technologies; identifying, characterizing and broadly assessing the impacts of these systems in the lower Ohio River Basin, from 1975 to 2000; and identifying and analyzing the major policy issues and options associated with these impacts.

A primary goal of the study is to identify the longer range socioeconomic, institutional and public health impacts, and to determine what effects various policy options might have in eliminating or alleviating these impacts. This preliminary report, however, focuses on the physical and biological impacts associated with the construction and operation of energy conversion technologies. These immediate, and relatively obvious, impacts must be identified and assessed in order to determine the delayed, less obvious socioeconomic, institutional and public health impacts that are related to changes in the physical and biological conditions in the study area. The present report serves to identify the direct and indirect impacts of energy conversion facilities in the Ohio River Basin to the year 2000. The organization and flow of the research effort to accomplish this is described in the following sections.

The leader of the University of Illinois mini-assessment team is Ross J. Martin, Director of the Engineering Experiment Station and Professor of Mechanical Engineering at the Urbana campus. He has been assisted in administering the effort by M. E. Wyman, Assistant to the Dean for Long-Range Planning and J. J. Desmond, Associate Director of the Engineering Experiment Station. The other members of the Urbana campus team, which has the primary responsibility for the physical and biological impact assessment, are:

Wayne David, Assistant Professor of General Engineering
Daniel Hang, Professor of Electrical and Nuclear Engineering
Jon Liebman, Professor of Environmental Engineering
Judith Liebman, Assistant Professor of Operations Research
G. Laurin Wheeler, Associate Research Biologist,
Environmental Research Laboratory

James P. Hartnett, Director of the Energy Resources Center at the University of Illinois Chicago Circle campus and Professor of Energy Engineering, is coordinator for the Chicago Circle campus segment of the team, which has the primary responsibility of the socioeconomic, institutional and public health aspects of the assessment. The other team members from Chicago Circle are:

Daniel J. Amick, Associate Professor of Sociology
Lyndon R. Babcock, Jr., Professor of Environmental Health Sciences, School of Public Health
Gilbert W. Bassett, Assistant Professor of Economics
Kathleen M. Brennan, Research Engineer, Energy Resources Center
Gary L. Fowler, Associate Professor of Geography
Steven D. Jansen, Research Geographer, Energy Resources Center
P. V. Sudhindra, Research Engineer, Energy Resources Center
Charles Teclaw, Research Economist, Energy Resources Center
Lettie M. Wenner, Assistant Professor of Political Science

The broad scope of the mini-technology assessment has necessitated the overview format of the material in this report. The impacts of the four Regional Technology Configurations (RTCs), or combinations of size, type and location of energy conversion facilities developed during the first part of the study, have been broadly identified and characterized. Individuals, groups or institutions affected in some manner by these impacts have been tentatively identified, and agencies and institutions that may have the capacity to respond to these impacts have been indicated. The researchers have made preliminary identification of the action options available to these agencies and the possible effects of these options on the RTCs.

A. INTRODUCTION

WORKING DRAFT

A.0 INTRODUCTION

A.1 BACKGROUND AND STATEMENT OF PROBLEM

The recent emphasis upon the development of domestic energy resources to meet an increased percentage of the United States' future energy demand requires that we understand the consequences of alternative policies of energy development upon the environment, and the social welfare and public health of the citizenry. The Integrated Assessment Program (IAP) of the Environmental Protection Agency (EPA) has been developed in response to this need.

The purpose of the IAP is to inform policy makers of the consequences of developing a new energy technology, extending a technology to a new geographical region, or greatly expanding an existing technology. The consequences include not only first-order environmental effects, but also all second-order and higher-order effects of the technologies themselves and of the environmental controls applied to them. Technology assessment is the principal method of impact analysis. These assessments are designed to inform policy makers of the options open to them and the possible consequences of those options.

A substantial part of the IAP's technology assessment activity involves the study of large-scale energy development in well-defined geographical regions which are likely to have major increases in energy production in the near or mid-term. The three regions selected in the contiguous United States are the Rocky Mountain and Plains States, Appalachia, and the lower Ohio River Basin.[1]

[1]The first phase of the western states assessment is completed (6) and the Appalachian study will begin shortly (3).

The purpose of the Ohio River Basin Energy Study (ORBES) is to analyze the full range of first-order, second-order, and higher-order impacts of selected energy conversion technologies from 1975 to 2000, and the policy options, including legislative actions, for alternative environmental control strategies.[1] The major objective is to identify technologies and siting patterns that are environmentally acceptable and to apply environmental controls and siting policies to them that will protect the environment and public health and welfare of residents of the region.

[1] An energy conversion technology is defined as an energy conversion facility (generating plant) as well as any associated facilities and technologies that support it.

A.2 DEFINITION OF STUDY REGION

The study region includes a total of 358 counties in Illinois, Indiana, Kentucky and Ohio (Figure A-1 and Table A-1). These counties account for 88 percent of the land area and 60 percent of the total population of the four states. Each county contains at least a portion of the Ohio River watershed or has the majority of its land area in the Eastern Interior Coal Field. Because of these criteria, the northern tier of counties in Illinois, Indiana and Ohio are excluded from the study region, despite the energy demands of large metropolitan areas such as Chicago, Gary, and Cleveland. The other boundaries of the study region follow state lines, and include all of Kentucky.[1]

[1] Fulton, Carlisle and Hickman Counties in the extreme southwestern part of Kentucky are included, even though they are not in the Ohio River watershed. Will and Rock Island Counties in Illinois are excluded because they are part of adjoining Standard Metropolitan Statistical Areas (SMSAs).

OHIO RIVER BASIN ENERGY STUDY REGION

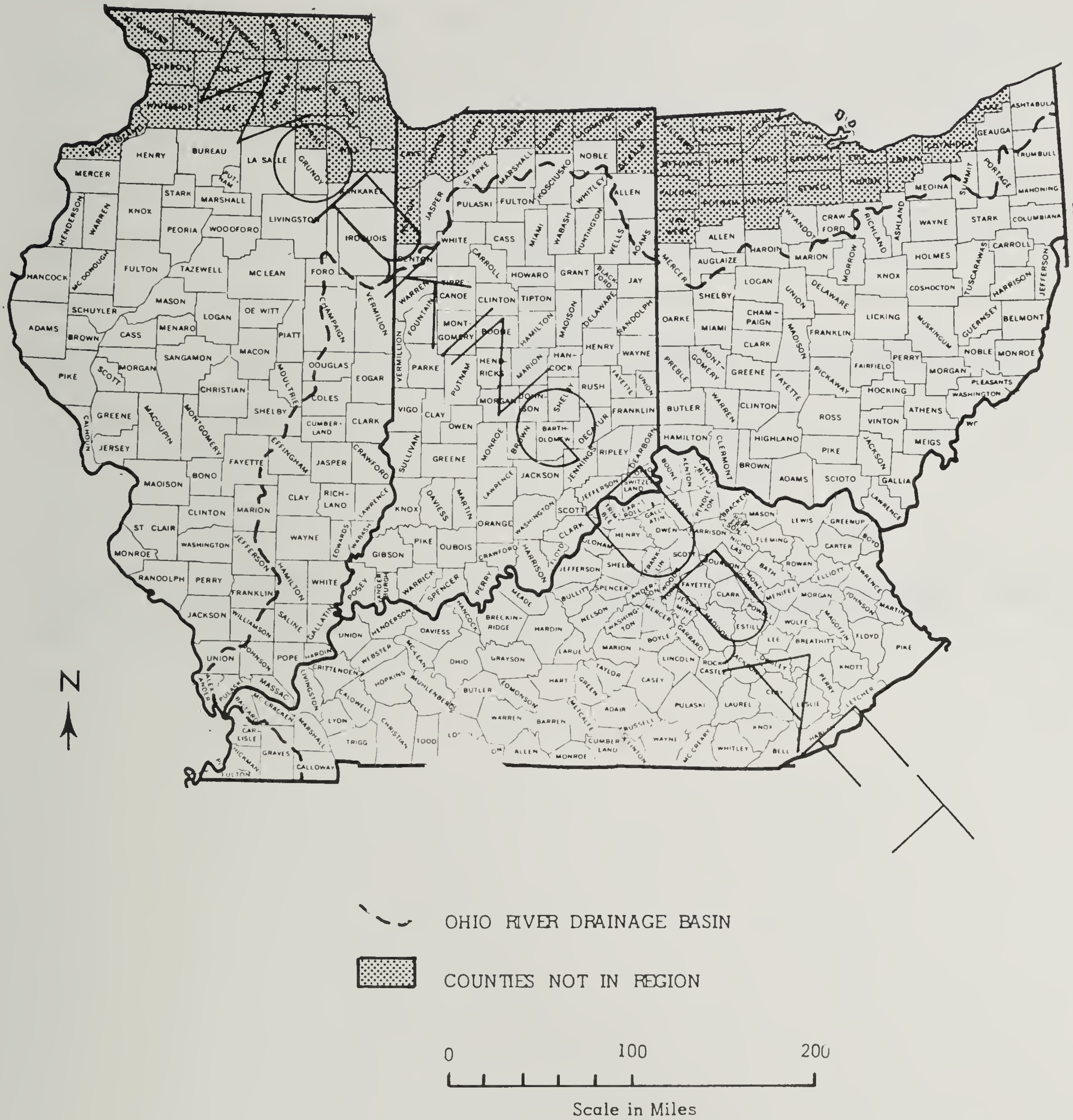


FIGURE A-1

SOURCE: U.S. Bureau of the Census

Prepared by Cartographic Laboratory and
Energy Resources Center, UICC

TABLE A-1

COUNTIES, LAND AREA AND POPULATION OF THE ORBES REGION

STATE	COUNTIES		LAND AREA[a]		POPULATION[b]	
	STATE	ORBES	STATE	ORBES	STATE	ORBES
Illinois	102	85	55,748	46,612	11,145.0	3,394.5
Indiana	92	83	36,097	32,149	5,311.0	4,100.5
Kentucky	120	120	39,650	39,650	3,396.0	3,396.0
Ohio	88	70	40,975	33,349	10,737.0	7,494.7
Totals	402	358	172,470	151,760	30,589.0	18,395.7

[a]In square miles.

[b]Estimates, in thousands, for July 1, 1974 (Ohio) and July 1, 1975 (Illinois, Indiana and Kentucky), as published in Current Population Reports, Series P-26, No. 122; No. 75-13; No. 75-14; and No. 75-17.

A.3 METHODOLOGY

A.3.1 COMPREHENSIVE TECHNOLOGY ASSESSMENT

Technology assessment is a class of policy studies which systematically examines the potential short-term impacts and longer-term consequences of new or expanded technologies upon society. The objective is to enable policy- and decision-makers to consider the main options and determine how they might more effectively intervene in the development of a prospective technology to better ensure its societal desirability.

The type of technology assessment used in the ORBES project is designed to be comprehensive. A comprehensive technology assessment is particularly concerned with the complex of second- and higher-order impacts which may have unintended, long-term consequences for the environment and the public health and welfare. Consequently, the assessment is conducted as an interdisciplinary team effort with the major emphasis upon structuring the problem (1,4, esp. Chapter 5). According to Arnstein (1,p.8):

> While even the most impeccable technology assessment cannot possibly anticipate all future societal impacts and consequences of a new technology, a comprehensive assessment can narrow the usual vast range of uncertainty by distinguishing what is known from what is not known; what is thought to be true from what is verifiable; what is feared from what is welcomed, and what competing and sometimes conflicting perspectives need to be taken into account. Thus the public dialogue which follows the release of an assessment can be based on the maximum amount of information that is available and an open explication of the mental models of the various [parties at interest].

In general, technology assessments of energy development have focused upon a particular energy conversion technology (e.g., geothermal) or a

limited range of impacts (2,5). By comparison, the technology assessment of the ORBES project is concerned with several combinations of energy conversion technologies, is regional in scale, and is comprehensive in nature.

A.3.2 PHASE I

Objectives

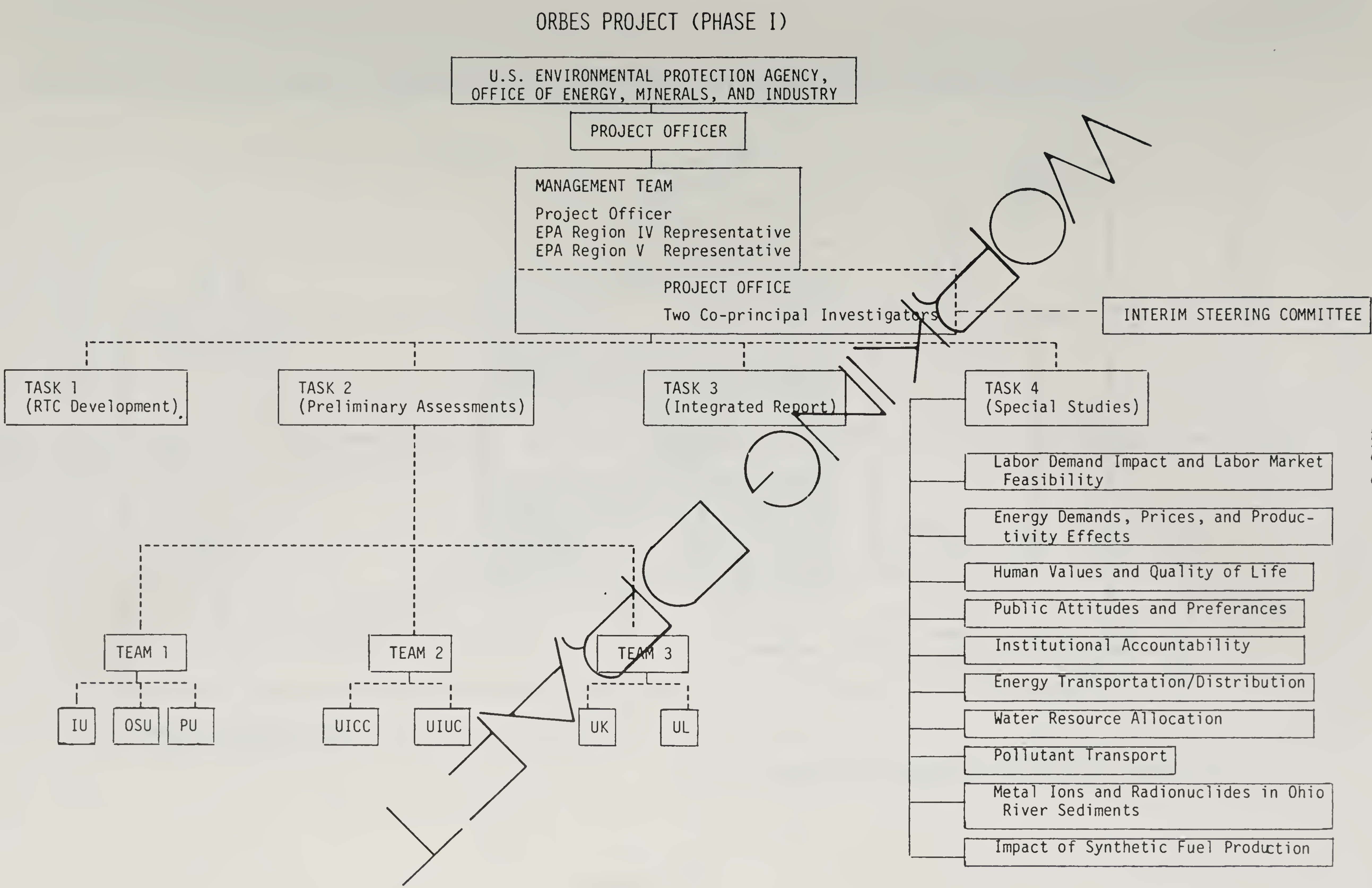
Phase I of the ORBES project has two primary objectives:

1. Outline the present and projected energy conversion technology configurations in the study region.
2. Perform an initial assessment of present and future regional impacts of these technologies.

The assessment is being performed by three semi-independent interdisciplinary research teams, with support from selected special studies (Figure A-2). The methodology which the University of Illinois team has designed for the assessment is shown in Figure A-3.

Task 1: Development of Plausible Future Regional Technology Configurations (RTCs)

The objective of Task 1 is to summarize present and selected alternative projected future energy conversion technologies in the lower Ohio River Basin in terms of the energy resource base, conversion systems and facility locations, environmental control technologies, and the institutions concerned with energy utilization and its environmental impacts. These plausible futures, or Regional Technology Configurations (RTCs), will serve as a baseline for subsequent technology assessments and the comparison of their impacts within the study region.



ORBES PROJECT (PHASE I)
U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF ENERGY, MINERALS, AND INDUSTRY
PROJECT OFFICER
MANAGEMENT TEAM
Project Officer
EPA Region IV Representative
EPA Region V Representative
PROJECT OFFICE
Two Co-principal Investigators
INTERIM STEERING COMMITTEE
TASK 1 (RTC Development)
TASK 2 (Preliminary Assessments)
TASK 3 (Integrated Report)
TASK 4 (Special Studies)
TEAM 1
IU
OSU
PU
TEAM 2
UICC
UIUC
TEAM 3
UK
UL
Labor Demand Impact and Labor Market Feasibility
Energy Demands, Prices, and Productivity Effects
Human Values and Quality of Life
Public Attitudes and Preferances
Institutional Accountability
Energy Transportation/Distribution
Water Resource Allocation
Pollutant Transport
Metal Ions and Radionuclides in Ohio River Sediments
Impact of Synthetic Fuel Production
WORKING DRAFT

FIGURE A-2

METHODOLOGY FOR A MINI-TECHNOLOGY ASSESSMENT OF ENERGY DEVELOPMENT IN THE LOWER OHIO RIVER BASIN 1975 TO 2000

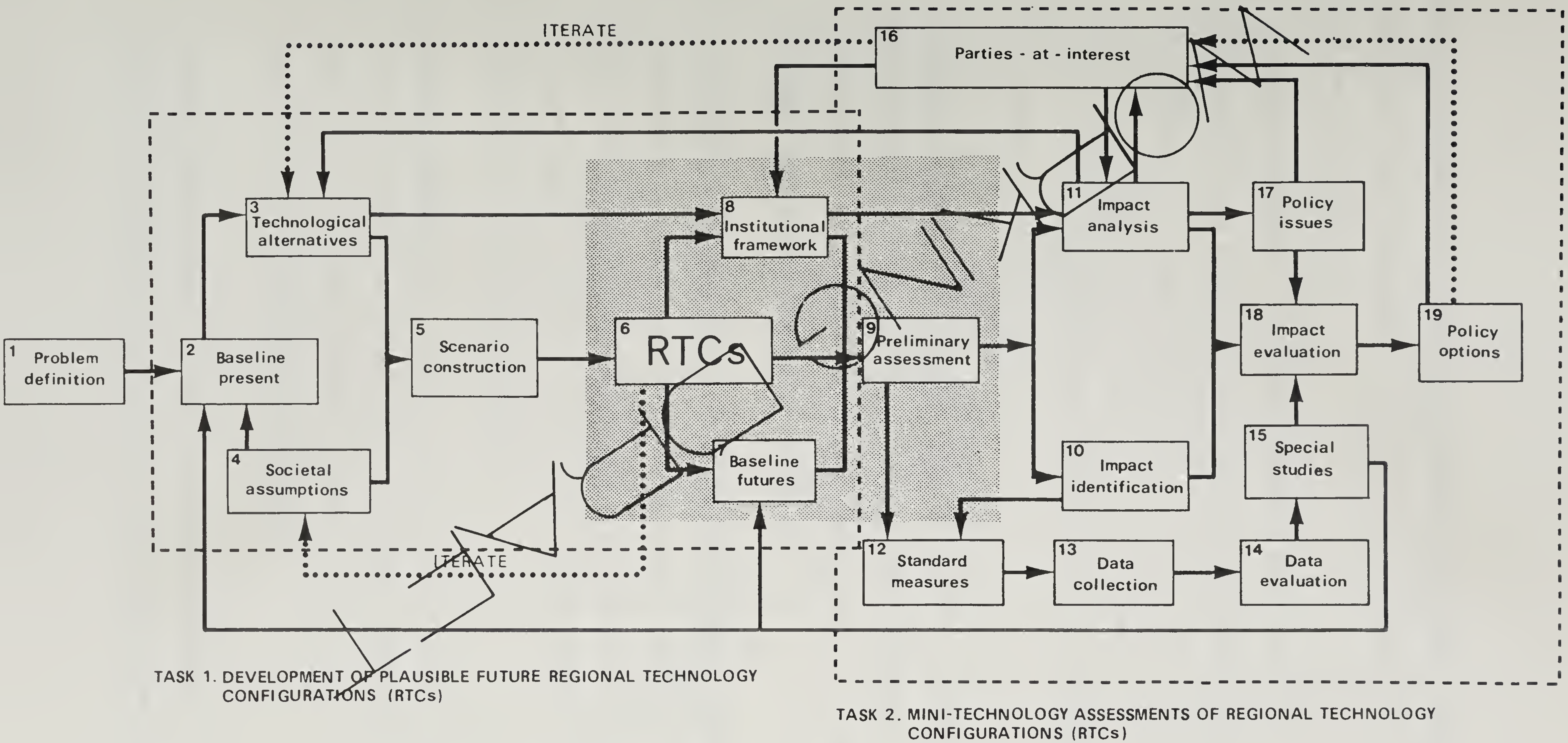


FIGURE A-3

Given the problem as defined above (Section A.1), Task 1 consists of the following steps (the number of each step corresponds to its appropriate box in Figure A-3).

1. <u>Problem Definition</u>: The major objective is to identify technologies and siting patterns that are environmentally acceptable and to apply environmental controls and siting policies to them that will protect the environment and public health, and maximize the social welfare of residents of the region.

2. <u>Baseline Present</u>: Describe existing (1970-1975) conditions in the study region, including present energy conversion technologies and resource bases, and projections of social, economic and demographic characteristics.

3. <u>Technological Alternatives</u>: Identify and describe alternative energy conversion technologies and control systems which are, or will be, available and which could be introduced into the region; identify and describe an appropriate set of technological trends and assumptions.

4. <u>Societal Assumptions</u>: Identify and describe sociopolitical trends and changes associated with new energy conversion technologies, including changes external to the region which may alter sociopolitical alignments.

5. <u>Scenario Construction</u>: Scenarios describe the probable level and type of energy development in the lower Ohio River Basin,

and bracket various projections of energy supply and demand in the nation and the region between 1975 and 2000.

6. Regional Technology Configurations (RTCs): RTCs are plausible energy conversion technologies, each based upon a different scenario. The RTCs vary in the number and size of facilities, the fuel mix and the geographical distribution of facility sites in the study region.

7. Baseline Futures: Describe the societal, political, and environmental trends and structures associated with each RTC.

8. Institutional Framework: Describe the institutions, both public and private, and the regulatory framework which directly or indirectly affects the RTCs.

Task 2: Mini-Assessment of Regional Technology Configurations

The objective of Task 2 is to conduct a mini-technology assessment of the energy conversion technologies projected by the RTCs. A mini-technology assessment is meant to be comprehensive in nature, but broad rather than deep.[1] By concentrating on broad-scale impacts at regional scale, researchers can work through the problem conceptually and develop a clear picture of detailed needs and research paths. Sophisticated modeling, quantification and collection of new data are not required. Rather, a reiterative review, critique and synthesis of available information and data is necessary. A mini-technology assessment is a means of identifying the boundaries of the study quickly on a low budget.

[1] The differences in prototype technology assessments are outlined by Arnstein, 1976.

Box 9 in Figure A-3 is the first step in Task 2. It initiates three interrelated assessment functions: data collection and evaluation, impact evaluation, and policy analysis.[1]

9. Preliminary Assessment: Identify specific approaches and methodologies to be used in the mini-technology assessments.

10. Impact Identification: Identify general categories of impact (e.g., social, economic, public health and environmental) and list specific impacts in each category.

11. Impact Analysis: Classify impacts as to first-, second-, and higher-order effects, and identify their interrelationships. The objective is to trace the chain of cause-and-effect relationships between the immediate, direct impact of energy conversion technologies and the second- and higher-order effects of long-term consequences. The latter include the impacts of environmental controls applied to the energy conversion technologies.

12. Standardized Measures: Develop standard classifications and measures for energy conversion technologies and their expected impacts that are consistent with current regulatory standards.

13. Data Collection: Collect and organize currently available data for impact analysis.

---

[1] The gray, screened area shown in Figure A-3 indicates the interaction between Tasks 1 and 2 necessary to complete the RTCs and begin the mini-technology assessment.

14. Data Evaluation: Evaluate the available data and identify areas in need of additional data or specialized analysis.

15. Special Studies: Provide special expertise, detailed analyses and data bases identified as essential for Impact Evaluation (box 18) as well as defining Baseline Present (box 2) and Baseline Futures (box 7).[1]

16. Parties at Interest: Identify groups likely to be affected by, or have an interest in, each impact. Groups include those who already have a special interest and those who might not be aware of potential future impacts affecting them.

17. Policy Issues: Describe the key policy issues associated with the impacts of each RTC. Policy issues are also of direct importance to defining Parties at Interest (box 16).

18. Impact Evaluation: Evaluate the impacts associated with each RTC, and compare the impacts within and between RTCs.

19. Policy Options: Identify the range of alternative strategies available for public policy makers to decide which policies to adopt to effect a particular type of environmental control strategy for new energy conversion technologies.

Policy Options may effect change through Parties at Interest (box 16) by altering the Institutional Framework (box 8) for all or certain aspects of the RTCs (box 6), or by supporting the development of one or several

---

[1]The Special Studies, which comprise Task 4, are listed in Figure A-2.

Technological Alternatives (box 3). The feedback loops in the policy studies subsystem indicate the pattern of interrelationships between the assessment of impacts, policy options, and energy conversion technologies.

REFERENCES

1. Arnstein, S. R., "Technology Assessment: Opportunities and Obstacles for Health Managers." Paper presented at the Second International Congress on Technology Assessment, University of Michigan, Ann Arbor, October 26, 1976.

2. Baldwin, Thomas E. and Others, A Socioeconomic Assessment of Energy Development in a Small Rural County: Coal Gasification in Mercer County, North Dakota. 2 Vols.; Argonne, Illinois: Energy and Environmental Systems Division, Argonne National Laboratory, August 1976.

3. Environmental Protection Agency, "A Technology Assessment of Energy Development in the Appalachian Region," RFPC1 76-0320.

4. Hetman, F. Society and the Assessment of Technology. Paris: Organization for Economic Co-operation and Development, 1973.

5. A Technology Assessment of Geothermal Energy Resource Development. Prepared by the Futures Group, Washington, D. C.: U. S. Government Printing Office, 1975.

6. White, J. L. (Jack), La Grone, F. S., and Others, Draft: First Year Report of a Technology Assessment of Western Energy Resource Development. Vol. 1, Summary. Washington: Environmental Protection Agency, n.d.

B. PRESENT (1975) AND PLANNED (1976-1985) ENERGY CONVERSION FACILITIES IN THE ORBES REGION

B.0 PRESENT (1975) AND PLANNED (1976-1985) ENERGY CONVERSION FACILITIES IN THE ORBES REGION

In 1975, Illinois, Indiana, Kentucky and Ohio had 58,647 MW(E) of installed generation capacity (Table B-1) (2). Three-quarters of this total, and the majority of each state's share, was in the counties which comprise the ORBES region.

TABLE B-1

INSTALLED AND PLANNED GENERATION CAPACITY IN ORBES STATES AND SUBREGIONS, IN MW(E)

	1975 INSTALLED CAPACITY			1985 PLANNED CAPACITY		
STATE	STATE	ORBES SUBREGION	PERCENTAGE OF STATE IN REGION	STATE	ORBES SUBREGION	PERCENTAGE OF STATE IN REGION
Illinois	25,044	13,134	52.4	44,134	21,279	48.2
Indiana	15,440	11,343	73.5	24,749	20,007	80.8
Kentucky	12,267	12,267	100.0	19,856	19,855	100.0
Ohio	27,392	21,903	80.0	37,465	27,334	73.0
TOTAL	80,943	58,647	73.2	126,204	88,475	70.1

Coal-fired plants accounted for 89.7% of the region's capacity, with oil (4.8%) and nuclear (4.8%) plants comprising most of the remainder. The plants are in places which are accessible to water supplies, coal fields and load centers (Figure B-1)[1] (1). They are concentrated along the main stem of the Ohio River and its main tributaries. Figure B-2 displays the transmission

[1] The facilities shown in Figure B-1 represent 95% of the installed generation capacity but only 55% of the facilities. Facilities having less than 25 MW(E) capacity are not shown.

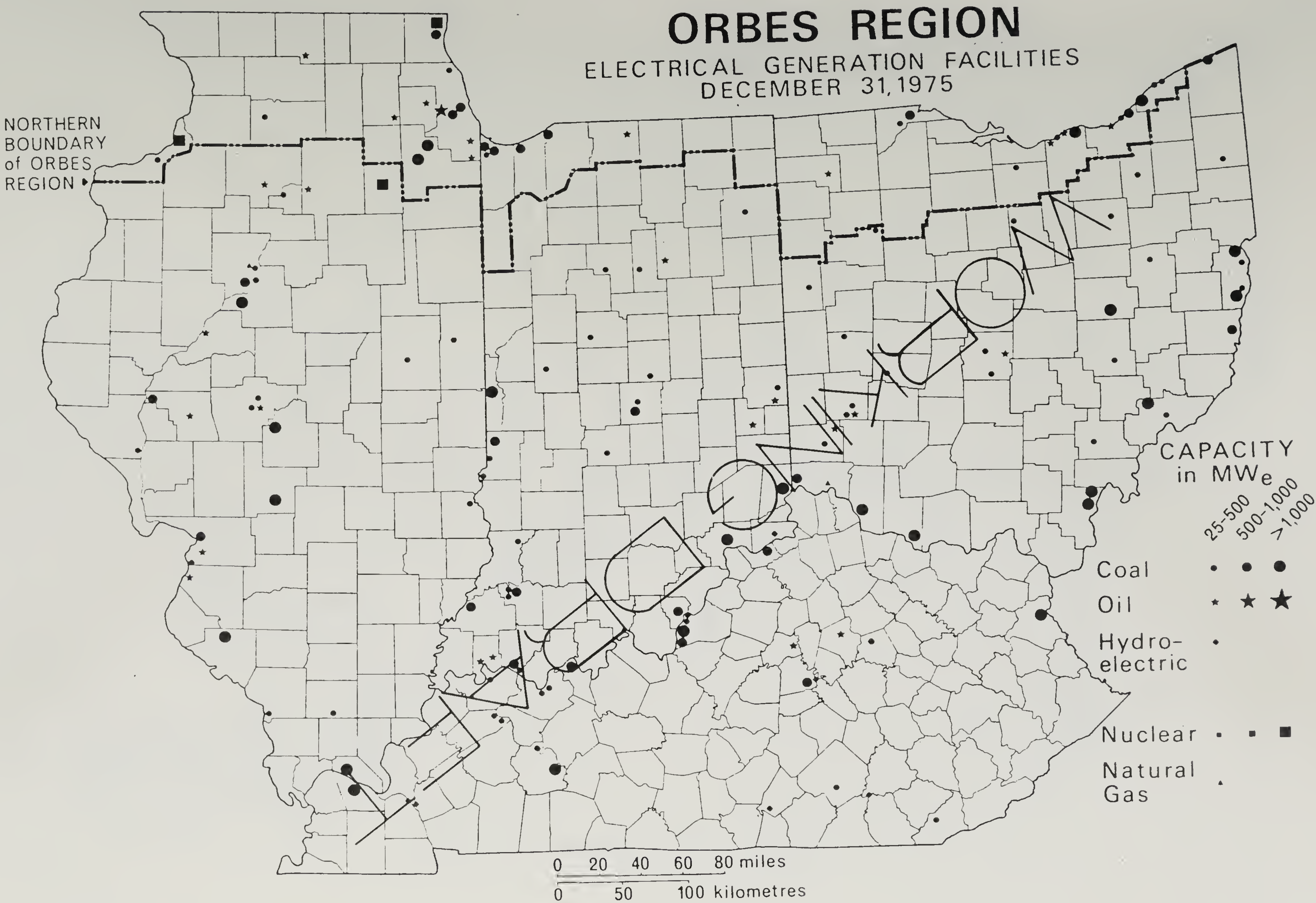

ORBES REGION
ELECTRICAL GENERATION FACILITIES
DECEMBER 31, 1975
NORTHERN BOUNDARY of ORBES REGION
CAPACITY in MWe
25-500
500-1,000
>1,000
Coal
Oil
Hydro-electric
Nuclear
Natural Gas
0 20 40 60 80 miles
0 50 100 kilometres

FIGURE B-1

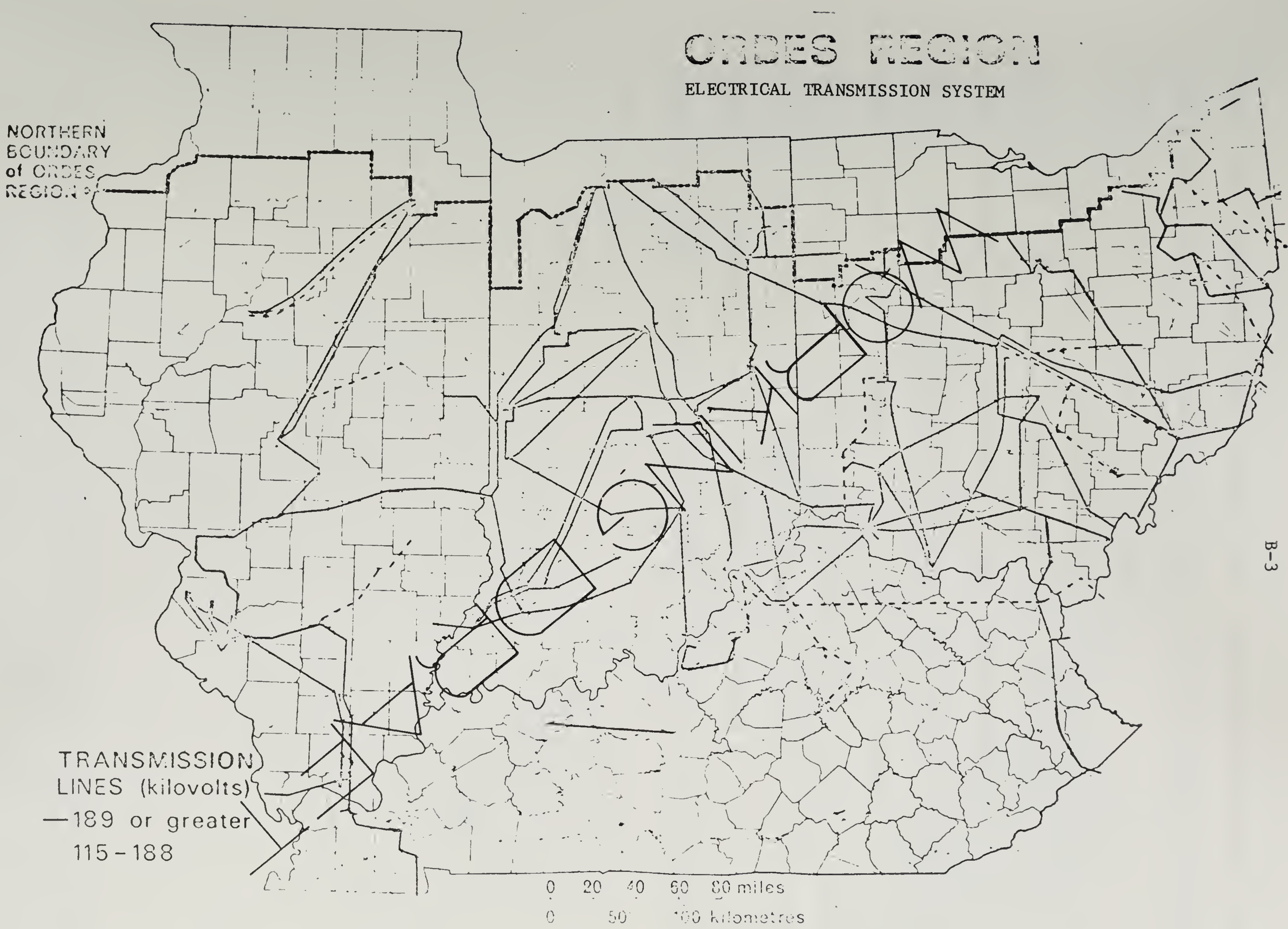

ORBES REGION
ELECTRICAL TRANSMISSION SYSTEM
NORTHERN BOUNDARY of ORBES REGION
TRANSMISSION LINES (kilovolts)
—189 or greater
115-188
0 20 40 60 80 miles
0 50 100 kilometres

FIGURE B-2

line network emanating from the main stem. Figure B-3 indicates the major coal fields within the ORBES region. These fields represent a present and projected primary fuel source for the region.

Utilities plan for capacity additions of 57.5% for the four states, and 50.9% in the ORBES region by 1985 (Table B-1). The majority of the increase is in Illinois, Indiana and Kentucky, with Indiana having the largest increase (76.4%). Additions to existing generation facilities are planned in nine counties, and new facilities are planned for eight counties which already have (1975) at least one plant. An additional nine plants are planned for counties which, at present, have no generation facilities (Figure B-4). Coal-fired plants will still account for an estimated 84.7% of the generation capacity in 1985. However, nuclear plants will have a larger share (10.6%) than in 1975.[1]

[1] The sites shown in Figure B-4 indicate plans of the utilities for capacity additions by the three regional reliability councils responsible for coordination of electrical generation in the ORBES region: Mid-America Interpool Network (MAIN), East Central Reliability Council (ECAR), and Southeastern Electric Reliability Council (SERC). These facilities are expected to be completed and operating by the end of 1985.

ORBES REGION

COAL RESERVES

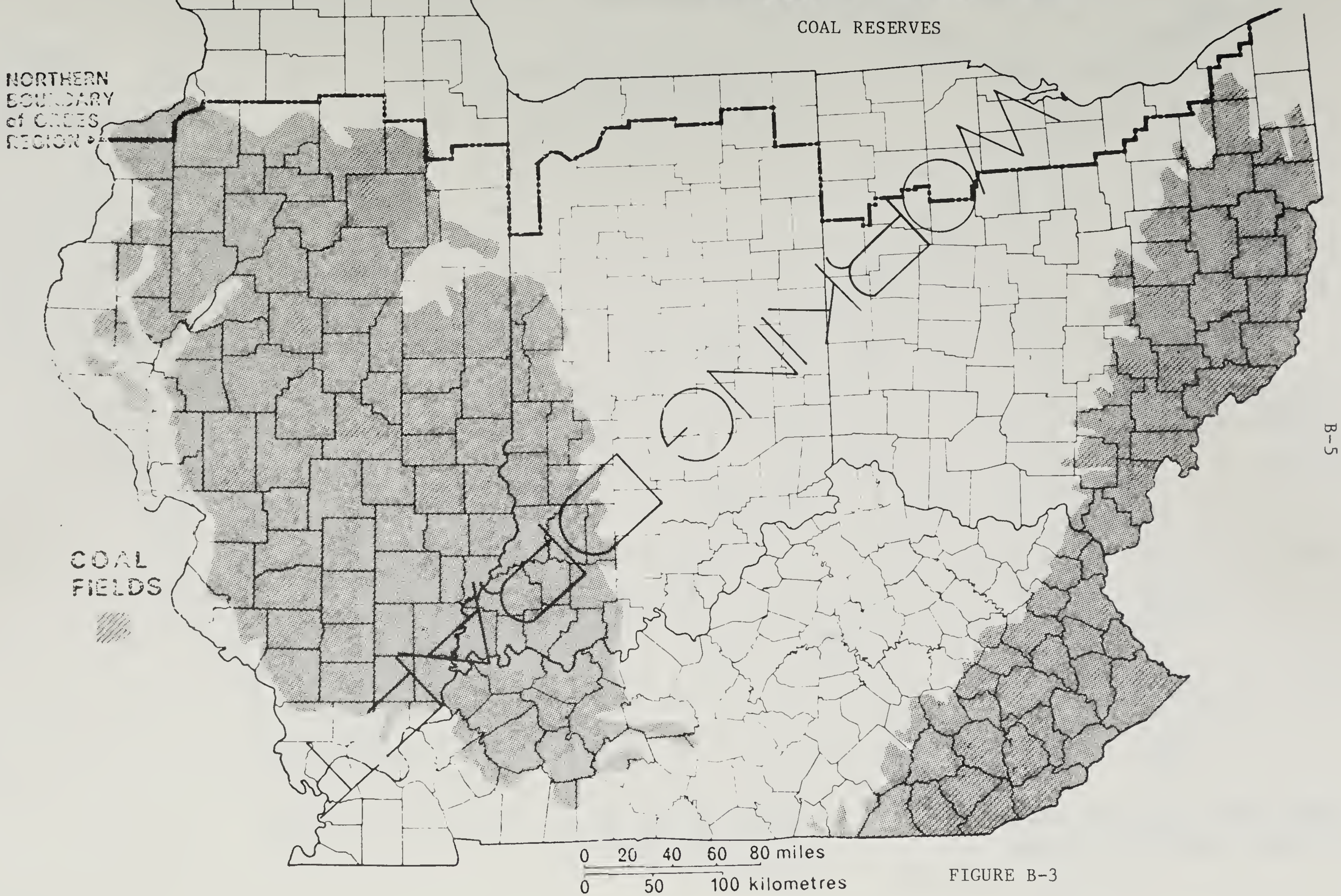


FIGURE B-3

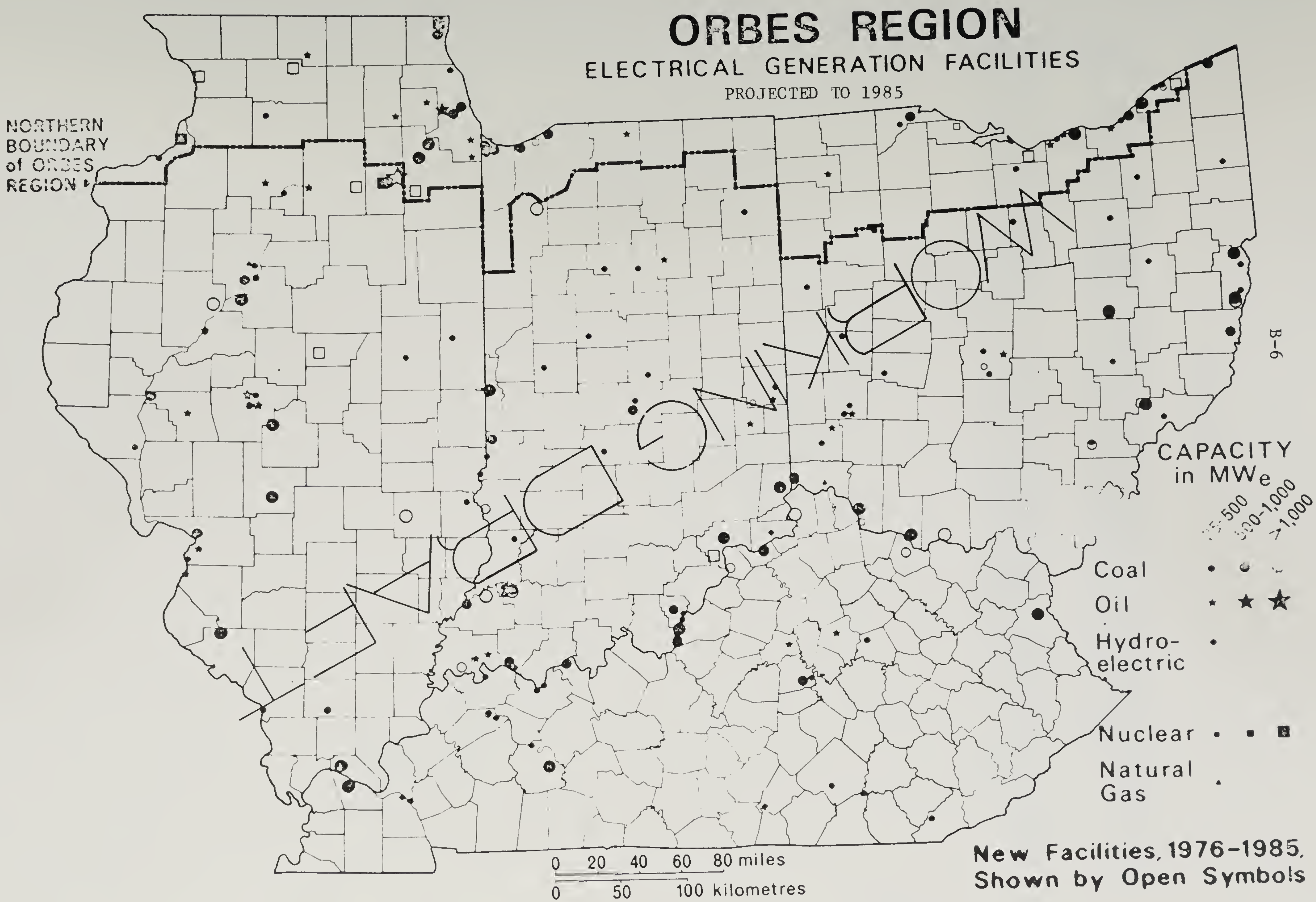

ORBES REGION
ELECTRICAL GENERATION FACILITIES
PROJECTED TO 1985
NORTHERN BOUNDARY of ORBES REGION
WORKING DRAFT
CAPACITY in MWe
500-1,000
>1,000
Coal
Oil
Hydro-electric
Nuclear
Natural Gas
0 20 40 60 80 miles
0 50 100 kilometres
New Facilities, 1976-1985, Shown by Open Symbols

FIGURE B-4

REFERENCES

1. Electrical Generation Capability in Illinois, Indiana, Kentucky, and Ohio and in the ORBES Region —1975 and 1985. Energy Resources Center, University of Illinois, Chicago, Illinois, November, 1976.

2. Forecasts of Electrical Power and Energy Requirements for the ORBES States and the ORBES Subregions through the Year 2000. Energy Resources Center, University of Illinois, Chicago, Illinois, December 10, 1976.

C. PROJECTIONS OF FUTURE ENERGY CONVERSION FACILITIES IN THE ORBES REGION (1975-2000) - FOUR SCENARIOS

C.0 PROJECTIONS OF FUTURE ENERGY CONVERSION FACILITIES IN THE ORBES REGION (1975-2000) - FOUR SCENARIOS

An objective of the Ohio River Basin Energy Study is to project a range of probable changes in the technical and societal aspects of the conditions that will result from the deployment of energy conversion systems in the ORBES region for the years 1975 through 2000. A series of multiple scenarios have been developed to meet these objectives. A scenario is an analytical projection which attempts to portray the future in response to a given set of assumptions about the future. A scenario puts into perspective what is likely to happen when the present is subjected to the passage of time and to a number of plausible "what-if" questions.

The scenarios are based upon existing estimates of future national and regional electrical energy demands. Important considerations are the growth rate of the population and the amount of energy (including electrical energy) per person that will be needed during the time period under consideration. Energy extraction capabilities, energy sources available for utilization, energy transportation, and energy handling and processing should also be addressed.

Four scenarios were developed: Scenario 1 uses the 1975 Bureau of Mines (BOM) (1) forecast as the basis for what is considered to be the highest probable limits of energy demand and generation (i.e., highest economic activity) in the U.S. for a given rate of population growth.[1] The fuel mix of energy conversion facilities was set at 80% coal and 20% nuclear facilities to be built between 1985 and 2000.

---

[1] Both the BOM and the Ford Tech Fix projections use the U.S. Bureau of the Census estimates for population growth.

Scenario 2 is identical to Scenario 1 in regard to the assumed levels of economic activity and population growth. Only the fuel mix is changed, i.e., 50% coal and 50% nuclear facilities, are presumed to be built between 1985 and 2000. The line labeled "Bureau of Mines" of Figure C-1 characterizes the growth of electrical production (capacity) under both Scenarios 1 and 2.

In Scenarios 3 and 4, a slower growth rate of electrical energy consumption and demand is used as a basis for projections. In the Ford Tech Fix scenarios (growing out of the Energy Policy Project of the Ford Foundation) (2) much fewer energy generating facilities are forecast for the year 2000. Scenarios 3 and 4 differ in that 3 assumes that 100% of the electrical generating capacity added or replaced will be coal fired. Scenario 4 presumes 100% nuclear replacements or additions. The line labeled "Ford Tech Fix" of Figure C-1 shows the growth of installed electrical production facilities under both Scenarios 3 and 4.

The differences between the BOM and Ford Tech Fix scenarios, in terms of electric generating facilities, are quite significant. The "x" on Figure C-1 shows us that by 1985 actual generating facilities now planned will lie somewhere between the two extremes. The word "extremes" is perhaps well chosen. In all likelihood, both the Bureau of Mines predictions and the Ford Tech Fix predictions represent extremes--one an extremely high and the other an extremely low projection of installed electrical power production capacity required. However, by analyzing the implications of these extreme, though plausible, futures, we are able to dramatically contrast the whole range of consequences and impacts that these very different futures will have upon the region.

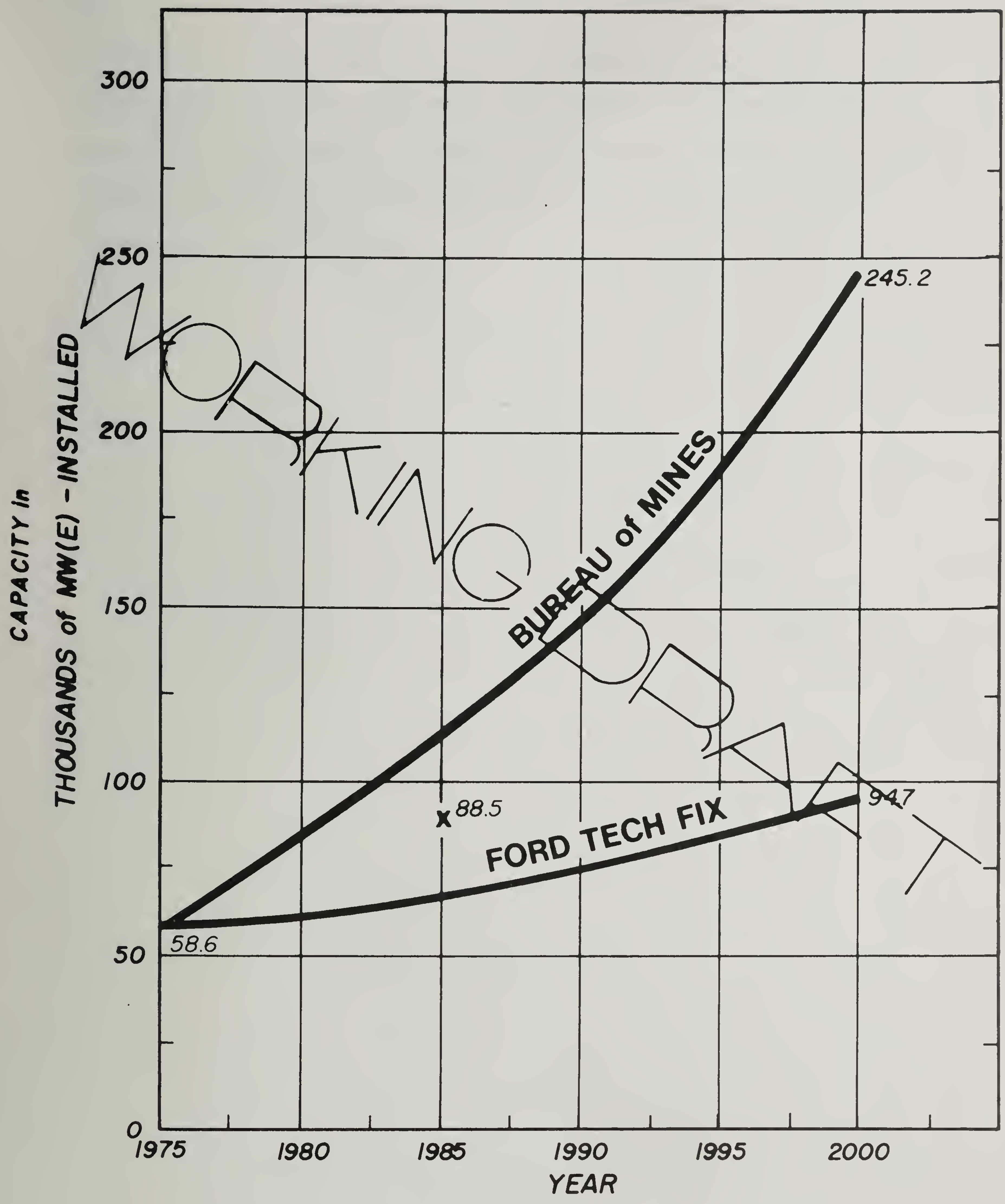


FIGURE C-1
GROWTH OF ELECTRICAL PRODUCTION - BOM AND FORD TECH FIX SCENARIOS

The effect is that through this process, we are able to circumscribe or bracket the upper and lower bounds of the problem. Successive phases of the ORBES study are likely to utilize scenarios which would fall within a yet more plausible range of possibilities. However, the present work will have defined the limits within which more likely futures might be projected.

C.1 DESCRIPTIONS OF BUREAU OF MINES SCENARIO

The projections of future electrical energy conversion facilities in the ORBES region from 1985 to 2000, based upon the Bureau of Mines (BOM) projections, presumes an approximate growth rate of 5.8% in electrical energy (1). In the BOM scenarios, it is assumed that 1975 planned capacity will come on line as presently planned by the utilities during the decade ending 1985. The other major features of the BOM forecast are:

1. Between 1974 and 2000, the per capita net electrical energy consumption is expected to grow from 30 million BTU equivalent to 112 million BTU; in the same period, per capita gross electrical consumption is expected to increase from 93 million BTU equivalent to 298 million BTU.

2. The economic activity, as measured by GNP, is strongly correlated with energy consumption. The anticipated high growth in economic activity implies increasing energy consumption in all sectors, including electrical generation.

3. The availability of primary fuels is relatively unrestricted, though their price effects are not known.

4. Major technological changes, such as the introduction of commercial breeder reactors and synthetic fuel plants, are expected between 1985 and 2000. (However, in this study, the RTCs do not consider the possibility of commercial breeder reactors by 2000 in the ORBES region.)

C.1.1 THE PROCESS OF PROJECTING INSTALLED GENERATING CAPACITY FOR ORBES REGION (BOM 1985-2000)

The projections of national generating capacity for 1985 and 2000 were allocated to each state and subregion within the study area. The additional number of plants required to replace those retiring during the period 1985-2000 was estimated by taking a percentage of the national total requirements, based on an assumed useful plant life of about 35 years.

The corresponding figures for each ORBES subregion were obtained by apportioning the state's capacity and additional unit requirements to the subregion on the basis of that subregion's percentage of the state's 1985 capacity. Details of the calculations are in reference (4).

The probable size, number, location, and fuel type of the generating plants to be constructed in the ORBES region between 1975 and 1985 are essentially known at this time because of the lengthy lead time required to develop such facilities (3). However, forecasting attributes of the additional generating capacity required for the 1985-2000 period depends upon several assumptions specified by the Task 1 team. One of the BOM-based RTCs was given a mix of 80% coal-fired and 20% nuclear-fueled units. The standard plant unit of either type was arbitrarily determined to be 1000 MW(E).

In order to project the requirements for generating capacity, the following selected operating parameters were assumed:

Annual Load Factor	47.8%
Conversion Efficiency	31% Nuclear 37% Coal
Reserve Capacity	15% of total installed MW(E) (same as 17.6% of peak load)

Given these parameters and the energy consumption projections in the electrical sector of the BOM projections, the required capacity to be installed in the United States by 1985 is 2,064,482 MW(E). The criterion used to apportion the national capacity to the individual states is that each state's share of the installed capacity will remain approximately the same in the years 1985 and 2000 as it was in the year 1975. Currently

the four states together account for approximately 16.8% of the installed capacity in the nation, and very nearly the same percentage in distributed electricity. The projected capacity required in each state is shown in Table C-1.

TABLE C-1

PROJECTED INSTALLED CAPACITY IN MW(E) IN THE FOUR STATES

State	1985 (Planned)	1985 (BOM)	2000 (BOM)
Illinois	44,134	49,480	108,117
Indiana	24,749	30,505	66,656
Kentucky	19,856	24,236	52,958
Ohio	37,465	54,119	118,254
TOTAL	126,204	158,340	345,985

In each state, the planned capacities recorded by the utility companies is less than the BOM projections (3). This shortfall was added to the capacity to be constructed between 1985 and 2000.

The fuel types and sites of the majority of the plants which are planned for 1976-1985 have been selected. Consequently, it is assumed that only the plants to be added between 1985 and 2000 will have the designated fuel mix between coal and nuclear; that is, 80% coal - 20% nuclear or 50% coal - 50% nuclear. It is also assumed that the rate of retirement of generating capacity is approximately 2% of the existing capacity in any given year, and that the apportionment of the state's projected capacity to the ORBES subregion within the state follows the same principle as that used to apportion the national capacity of the four states (4).

The following tables, C-2 through C-5 (see pages C.1-5 & 6), summarize the projected generating capacity for the ORBES subregion in each state as a function of time (1985 vs. 2000) and RTC (4).

As a result of this analysis (and the Project's Office's request that only three 1000 MW(E) nuclear plants be located in Kentucky), the projected number of 1000 MW(E) plant units to be sited in the ORBES subregions for the BOM scenario is distributed as shown in Table C-6. The growth in total installed capacity for the two BOM scenarios is shown graphically in Figure C-2 (page C.1-7).

TABLE C-6

PROJECTED NUMBER OF 1000 MW(E) PLANT UNITS TO BE SITED IN THE ORBES SUBREGIONS BETWEEN 1985 AND 2000

ORBES SUBREGIONS	NUMBER OF UNITS: 50-50 Fuel Mix			NUMBER OF UNITS: 80-20 Fuel Mix		
	COAL	NUCLEAR	TOTAL	COAL	NUCLEAR	TOTAL
Illinois	16	15	31	25	6	31
Indiana	17	17	34	25	7	34
Kentucky	17	17	34	31	3	34
Ohio	30	30	60	48	12	60
TOTAL	80	79	159	131	28	159

C.1.2 REGIONAL TECHNOLOGY CONFIGURATIONS

Each mini-assessment team developed a list of candidate counties within its own state(s) which appear suitable for the installation of coal-fired plants, nuclear-fueled plants, or both. The criteria used in siting included the availability of water, population density and

TABLE C-2

PROJECTED POWER, IN MW(E), IN ORBES-ILLINOIS FOR THE YEAR 2000
WITH DIFFERENT FUEL MIXES

ORBES-KENTUCKY BOM

FUEL	1985 PLANNED	50-50 Fuel Mix Additions 1985-2000	50-50 Fuel Mix Removals 1985-2000	50-50 Fuel Mix Totals for 2000	80-20 Fuel Mix Additions 1985-2000	80-20 Fuel Mix Removals 1985-2000	80-20 Fuel Mix Totals for 2000
Coal	13,899	15,573	2,148	27,324	24,917	2,148	36,668
Nuclear	6,243	15,573	---	21,816	6,229	---	12,472
Oil	1,043	1,605	383	2,265	1,605	383	2,265
Nat Gas	88	674	45	717	674	45	717
Hydro	6	---	---	6	---	---	6
TOTAL	21,279	33,425	2,576	52,128	33,425	2,576	52,128

TABLE C-3

PROJECTED POWER, IN MW(E), IN ORBES-INDIANA FOR THE YEAR 2000
WITH DIFFERENT FUEL MIXES

ORBES-INDIANA BOM

FUEL	1985 PLANNED	50-50 Fuel Mix Additions 1985-2000	50-50 Fuel Mix Removals 1985-2000	50-50 Fuel Mix Totals for 2000	80-20 Fuel Mix Additions 1985-2000	80-20 Fuel Mix Removals 1985-2000	80-20 Fuel Mix Totals for 2000
Coal	17,001	17,155	2,466	31,690	27,448	2,466	41,983
Nuclear	2,260	17,155	---	19,415	6,862	---	9,122
Oil	633	1,496	154	1,975	1,496	154	1,975
Nat Gas	26	743	52	717	743	52	717
Hydro	87	---	---	87	---	---	87
TOTAL	20,007	36,549	2,672	53,884	36,549	2,672	53,884

TABLE C-4

PROJECTED POWER, IN MW(E) IN ORBES-KENTUCKY FOR THE YEAR 2000
WITH DIFFERENT FUEL MIXES

ORBES-KENTUCKY BOM

FUEL	1985 PLANNED	50-50 Fuel Mix Additions 1985-2000	50-50 Fuel Mix Removals 1985-2000	50-50 Fuel Mix Totals for 2000	80-20 Fuel Mix Additions 1985-2000	80-20 Fuel Mix Removals 1985-2000	80-20 Fuel Mix Totals for 2000
Coal	18,570	16,771	2,425	32,916	30,541	2,425	46,686
Nuclear	0	16,770	---	16,770	3,000*	---	3,000
Oil	341	1,447	136	1,652	1,447	136	1,652
Nat Gas	130	726	51	805	726	51	805
Hydro	815	---	---	815	---	---	815
TOTAL	19,856	35,714	2,612	52,958	35,714	2,612	52,958

*According to the Project Office, three 1000 MW(E) nuclear plants are projected for Kentucky.

TABLE C-5

PROJECTED POWER, IN MW(E) IN ORBES-OHIO FOR THE YEAR 2000
WITH DIFFERENT FUEL MIXES

ORBES-OHIO BOM

FUEL	1985 PLANNED	50-50 Fuel Mix Additions 1985-2000	50-50 Fuel Mix Removals 1985-2000	50-50 Fuel Mix Totals for 2000	80-20 Fuel Mix Additions 1985-2000	80-20 Fuel Mix Removals 1985-2000	80-20 Fuel Mix Totals for 2000
Coal	25,495	29,402	3,396	51,501	47,942	3,396	69,141
Nuclear	875	29,401	---	30,276	11,761	---	12,636
Oil	921	2,618	284	3,255	2,618	284	3,255
Nat Gas	2	1,275	72	1,205	1,275	72	1,205
Hydro	42	---	---	42	---	---	42
TOTAL	27,335	62,696	3,752	86,279	62,696	3,752	86,279

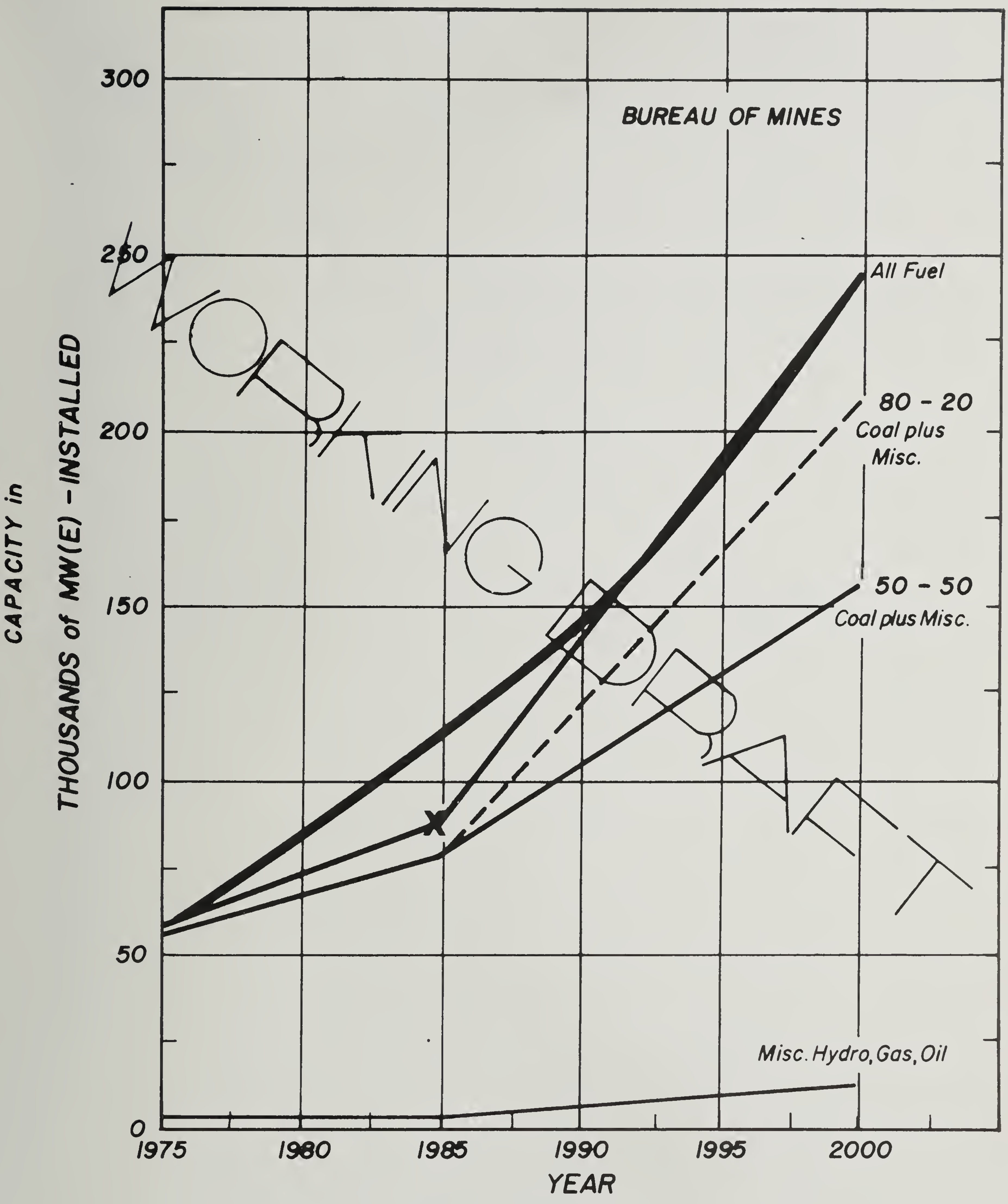


FIGURE C-2

GROWTH IN TOTAL INSTALLED CAPACITY - TWO BOM SCENARIOS

distribution, seismic activity, local environmental conditions, and preexisting power plants. The Illinois team followed site selection procedures used by utility companies, with review by representatives of major utilities in Illinois (5).

The final sites (counties) selected, by number and type of facility for each fuel mix and ORBES subregion, are included in Appendix I. Figures C-3 and C-4 provide maps showing where power generating facilities would be located, by county, under the two BOM scenarios

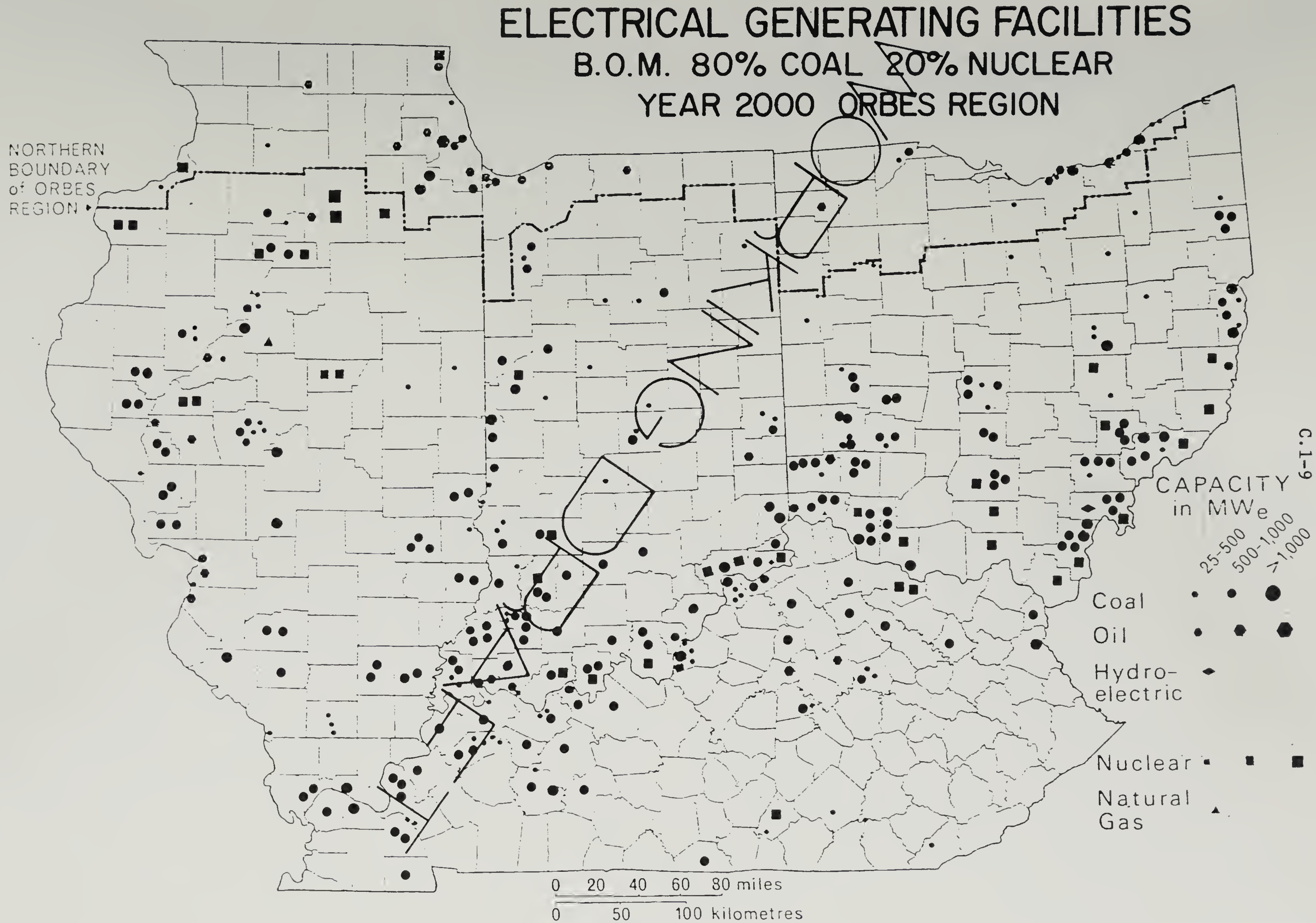

ELECTRICAL GENERATING FACILITIES
B.O.M. 80% COAL 20% NUCLEAR
YEAR 2000 ORBES REGION
WORKING DRAFT
NORTHERN BOUNDARY of ORBES REGION
CAPACITY in MWe
25-500
500-1,000
>1,000
Coal
Oil
Hydro-electric
Nuclear
Natural Gas
0 20 40 60 80 miles
0 50 100 kilometres

FIGURE C-3

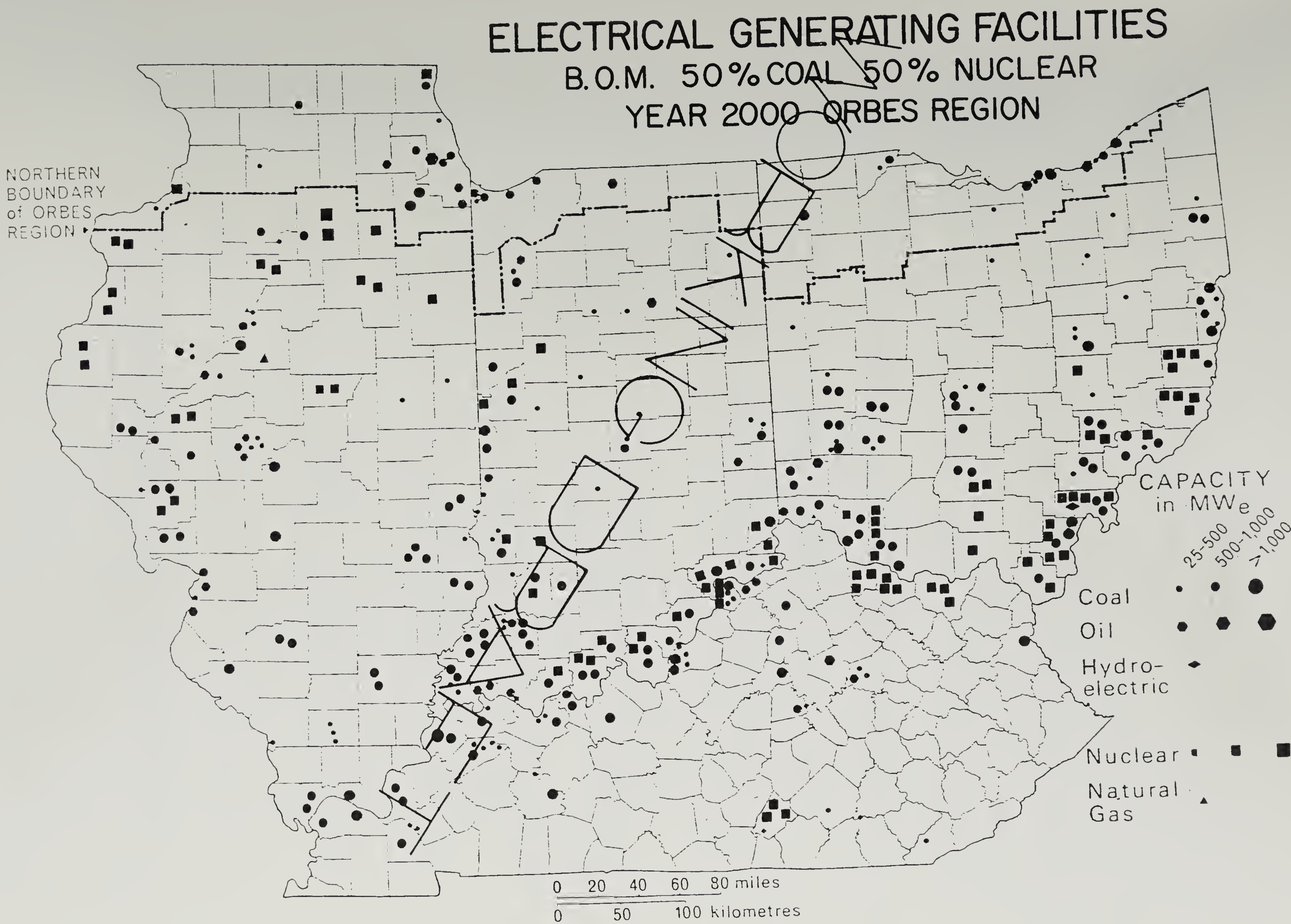

ELECTRICAL GENERATING FACILITIES
B.O.M. 50% COAL 50% NUCLEAR
YEAR 2000 ORBES REGION
NORTHERN BOUNDARY of ORBES REGION
CAPACITY in MWe
25-500
500-1,000
>1,000
Coal
Oil
Hydro-electric
Nuclear
Natural Gas
0 20 40 60 80 miles
0 50 100 kilometres

FIGURE C-4

C.2 DESCRIPTION OF FORD TECH FIX SCENARIO

The projections of future energy conversion facilities in the ORBES region from early 1970 to 2000, based upon the Ford Tech Fix (2), presumes an approximate growth rate of 1.9% in electrical energy consumption. The major assumptions of the Ford Tech Fix scenario are:

1. Long-term energy prices and government policies will encourage greater efficiency in energy consumption.

2. Between 1973 and 2000 the per capita net electrical consumption is expected to grow from 30 million BTU to 43 million BTU; in the same period the per capita gross energy consumption to generate electrical energy is expected to increase from 90 million BTU to 117 million BTU.

3. The nation will benefit from direct energy savings resulting from the application of energy conservation technologies at the point of energy use, and indirect energy savings in the energy processing sector.

4. The existing apparent positive correlation between GNP and energy consumption need not hold in the future and hence it is possible to reduce energy needs without adversely affecting the overall economy. As a result of energy savings, the cumulative reduction in GNP will be small, about 1.5% less in 1985 and 4% less in 2000.

5. Capital investment in energy savings technologies will be less than that required to continue investing in new energy conversion facilities at the present national rate of growth.

6. Electricity (and petroleum) will be expensive forms of energy.

7. The U.S. population will be 236 million in 1985 and 265 million in 2000. (This population growth corresponds to that assumed in the BOM scenario.)

C.2.1 THE PROCESS OF PROJECTING INSTALLED GENERATING CAPACITY BY ORBES SUBREGION (FORD TECH FIX 1975-2000)

The Ford Tech Fix is a more complicated scenario than the BOM scenario. Many of the assumptions involved are not explicitly stated and most are interrelated.

The selected energy conversion operating parameters for this scenario are identical to those in the BOM scenario.

Annual Load Factor	47.8%
Conversion Efficiency	31% Nuclear 37% Coal
Reserve Capacity	15% of installed MW(E) (same as 17.6% peak load)

These operational parameters, in conjunction with the national Ford Tech Fix scenario are invoked to scale down first to the four state region and then to the smaller ORBES region.

Other parameters, such as plant retirement rate and peak load capacity, used in developing the regional Ford Tech Fix scenario are the same as in the BOM scenario. The method of apportioning the U.S. forecast for capacity to the four states is identical to that detailed in the BOM scenario. Table C-7 shows the anticipated installed capacity in the four states using the Ford Tech Fix model.

As can be seen from this table, the installed capacity for 1985 resulting from the currently planned additions and removals by utilities from 1976 to 1985 is considerably in excess of Ford Tech Fix requirements in the four states. A corresponding situation holds for the ORBES region of the four states. Because of this, it has been proposed by the Illinois

group that delay factors be introduced into planned capacity additions between 1976-1985. At the request of the ORBES Project Office, the Illinois group has developed a detailed plan for reprogramming the on-line activation of new installed electrical power capacity in order to more closely track the power demand between 1985-2000 projected by the Ford Tech Fix scenario.

TABLE C-7
PROJECTED INSTALLED CAPACITY IN MW(E) IN THE FOUR STATES
1985 AND 2000 (FORD TECH FIX)

State	1985 (Planned)	1985 (Ford Tech Fix)	1985 (Ford Tech Fix)
Illinois	44,134	29,300	41,753
Indiana	24,749	18,064	25,741
Kentucky	19,856	14,352	20,451
Ohio	37,465	32,047	45,667
TOTAL	126,204	93,763	133,612

The procedure utilized is as follows:

a. The originally planned power plant capacity additions and removals (1976-1985) for the ORBES region were noted from the Task 1 report by year of planned activity and type of fuel and listed by ORBES states on Table C-8.

b. Table C-9 shows the Ford Tech Fix projected installed capacity required for the ORBES region for each year (1975-2000). Also it lists the proposed installed capacity for the years 1975 to 1994.

TABLE C-8

ORIGINAL PLANNED ADDITIONS AND REMOVALS (1975-1985)*

ORBES - ILLINOIS

Year	Coal	Nuclear	Oil	Gas	Hydro	Unknown
1976	400			42		
1977	550 178					
1978	450 173	1078				
1979	400	1078				
1980						
1981	550 20	950	-25,22 50			
1982						
1983	600 150					
1984	550,20 600	950	50			
1985			-50			
TOTAL	+4641	4056	+122-75	42		

ORBES - INDIANA

Year	Coal	Nuclear	Oil	Gas	Hydro	Unknown
1976	650 477					
1977	532					
1978	668					
1979	265 668 527					
1980						
1981	490 490		-1			
1982	532		3.5	2		
1983		1130				
1984	350	1130				
1985	100 650					
TOTAL	6399	2260	+3.5-1	2		

*See Tables lg/h-2, 4, 6, and 8 in Task 1 Report.

(continued)

TABLE C-8 (continued)

ORBES - KENTUCKY

Year	Coal	Nuclear	Oil	Gas	Hydro	Unknown
1976	300		65			
1977	500					
	425					
1978						
1979	495-59					
	200					
1980	500					
1981	500,669					
	495-130					
1982						
1983	500-71		65			
1984	500 200 800					
	495 669 -68					
1985	650 -111					
TOTAL	+7898-439		130			

ORBES - OHIO

Year	Coal	Nuclear	Oil	Gas	Hydro	Unknown
1976	375		-2			
1977	615			-111	40	
1978	557					
	375			-108		
1979		878				-130
1980	-64					-53
1981	661					
	375					
1982						
1983	661					
	375					
1984	615					
1985						
TOTAL	4609-64	878	-2	-219	40	-183

TABLE C-9

A PROPOSED SYSTEM FOR THE FORD TECH FIX PROJECTION

A System for Delaying Installation of Plants in Order to Meet the Ford Tech Fix Projection

Year	Ford Tech Fix Projection	Installed Capacity	Total New Capacity For Year	Coal	Nuc	Oil	Gas	Hydro	Unknown
1975	~ 58,600	58,646							
1976	~ 59,400	60,953	2307	2202		63	42		
1977	~ 60,200	63,682	2729	2800			-111	40	
1978	~ 61,000	63,574					-108		
1979	~ 61,800	64,035	461	591					-130
1980	~ 62,500	64,475	440	493					- 53
1981	~ 63,200	64,987	512	538		-26			
1982	~ 64,000	65,482	495	495					
1983	~ 64,800	65,959	477	477					
1984	~ 65,600	66,156	197	197					
1985	66,465	66,522	366	416		-50			
1986	68,052	68,394	2646-774*	1568	1078				
1987	69,678	69,679	2059-774	1181	878				
1988	71,343	71,470	2565-774	1415	1078	72			
1989	73,048	73,300	2604-774	1654	950				
1990	74,793	74,909	2383-774	1182	1130	69	2		
1991	76,580	76,721	2586-774	1636	950				
1992	78,410	78,412	2465-774	2465					
1993	80,283	80,672	3034-774	2984		50			
1994	82,201	81,778	1880-774	750	1130				
1995	84,165								
1996	86,176								
1997	88,235								
1998	90,343								
1999	92,501	(See Table C-10)							
2000	94,711								

*For the ORBES region 11,610 MW(E) of capacity will be retired from 1985-2000. If it is assumed to be done linearly, 774 MW(E) will be retired each year.

By 1994, the net added capacity originally planned for the period 1975-1985 meets the growth requirement of the Ford Tech Fix scenario. The third column shows the net capacity to be added to the ORBES region for each year and the additional columns show the type of fuel for the plants being added or removed. Note that for the years 1986 through 1994 the prorated removal of capacity equals 774 MW(E) per year. Also note that the "installed capacity" on this table considerably exceeds the Ford Tech Fix requirements at the present time (1977) and is then linearized to meet requirements of the scenario in 1985. This result is also apparent from the curves in Figure C-5.

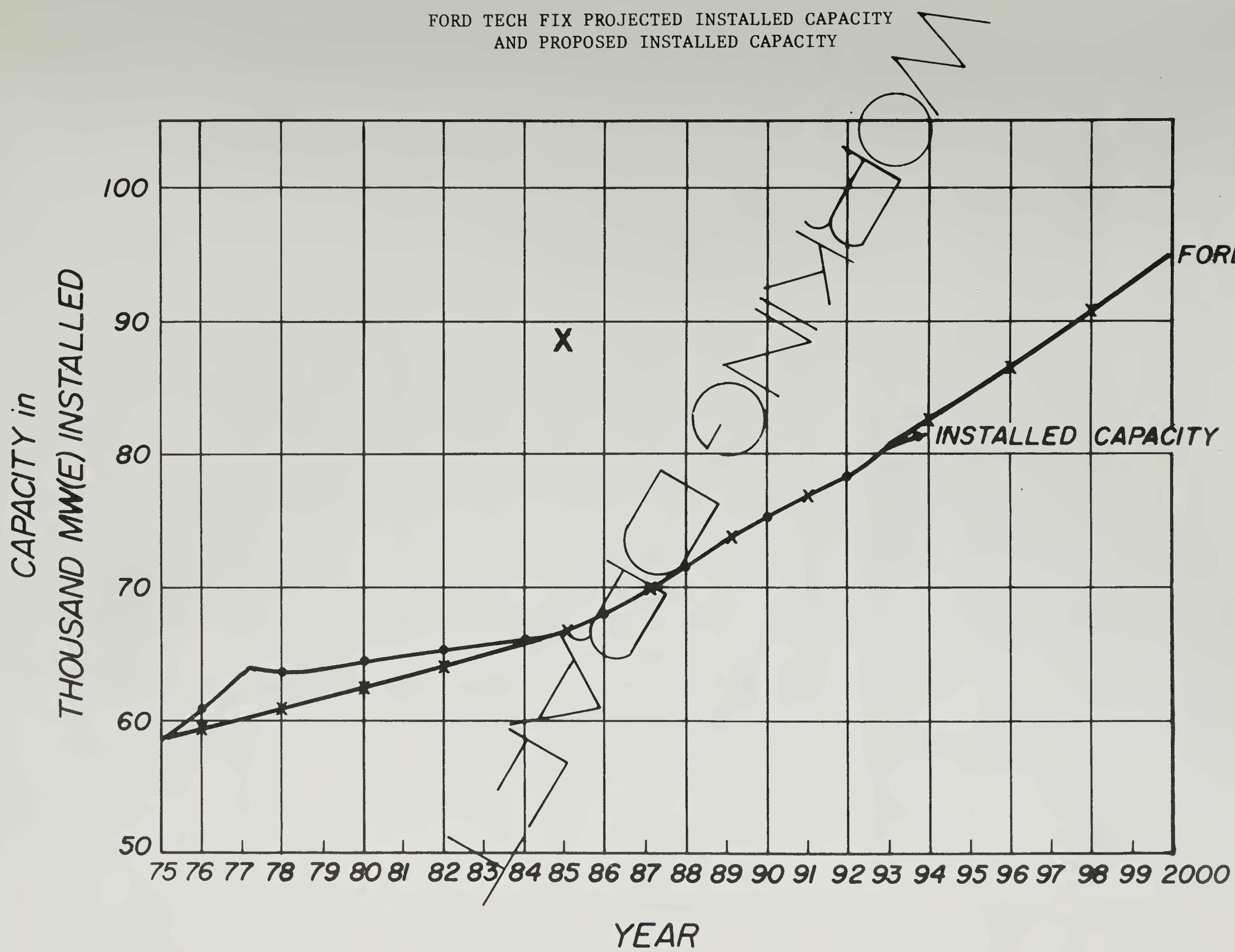
c. Table C-10 programs the additions of new 600 MW(E) coal-fired plants or new 1000 MW(E) nuclear plants needed to meet the Ford Tech Fix scenario to the year 2000. These 16 nuclear plants or 27 coal-fired plants equal the net additional capacity originally planned for addition between 1985 and 2000. Note the estimated removal of 774 MW(E) capacity for each year from 1994 to 2000 on this table.

d. Table C-11 provides the proposed new time sequence by state for the additions and removals for all originally scheduled plant additions and removals (1975-1985) as detailed by Task 1 for the ORBES region.

e. Tables in Appendix II provide for each state the detailed new schedule of plant additions and removals (including name, location, capacity, and fuel type) for the period

Figure C-5

FORD TECH FIX PROJECTED INSTALLED CAPACITY
AND PROPOSED INSTALLED CAPACITY



1976 to 1994 as well as a schedule and target county(s) for the addition of either 600 MW(E) coal-fired plants or 1000 MW(E) nuclear plants.

The above procedure and the resulting new schedule of plant additions avoid the substantial "overshoot" of installed capacity in 1985 which would have resulted from the originally planned schedule of plant additions and removals (1975-1985) described in Task 1.

Figures C-6 and C-7 following the tables provide maps of where power generating facilities would be located, by county, under the two Ford Tech Fix scenarios.

TABLE C-10

DATES FOR NEW PLANTS FOR FORD TECH FIX 1994 TO 2000[1]

Year	Projected Capacity	Installed Capacity[2]	New Capacity Needed	100% Nuclear New Plants	100% Nuclear Cumulative New Plants	100% Coal New Plants	100% Coal Cumulative New Plants
1994	82,201	81,778	423	1	1	1	1
1995	84,165	81,004	3,161	3	4	5	6
1996	86,176	80,230	5,946	2	6	4	10
1997	88,235	79,456	8,779	3	9	5	15
1998	90,343	78,682	11,661	3	12	5	20
1999	92,501	77,908	14,593	2	15	5	25
2000	94,711	77,134	17,577	1	16	2	27

[1]These represent the plants beyond those originally planned for installation in the period 1976 to 1985.

[2]For the ORBES region 11,610 MW(E) of capacity will be retired from 1985-2000. If it is assumed to be done linearly, 774 MW(E) will be retired each year.

TABLE C-11

NEW DATES FOR BRINGING PLANTS ON-LINE: 1976-1994[1]

ORBES ILLINOIS

Year	Coal		Nuc	Oil	Gas	Hydro
1976	400		-	-	42	
1977	550 178					
1978						
1979	450					
1980						
1981	-		-	-25		
1982						
1983	173					
1984						
1985	-		-	-50		
1986	400		1078			
1987	20					
1988	550		1078	72		
1989			950			
1990	150					
1991	600		950			
1992						
1993	550 600	20	-	50		

[1]These represent the plants to be added or removed under the new time schedule in place of the original schedule (1976-1985).

(continued)

TABLE C-11 (continued)

NEW DATES FOR BRINGING PLANTS ON-LINE: 1976-1994[1]

ORBES INDIANA

Year	Coal	Nuc	Oil	Gas	Hydro
1976	650 477				
1977	53[illegible]				
1978					
1979					
1980					
1981	668	-	-1		
1982					
1983					
1984	265				
1985	527				
1986	668				
1987					
1988	490				
1989	490				
1990	532	1130	3.5	2	
1991					
1992	350				
1993	650				
1994	100	1130			

[1]These represent the plants to be added or removed under the new time schedule in place of the original schedule (1976-1985).

(continued)

TABLE C-11 (continued)

NEW DATES FOR BRINGING PLANTS ON-LINE: 1976-1994[1]

ORBES KENTUCKY

Year	Coal	Nuc	Oil	Gas	Hydro
1976	300		65		
1977	500 425				
1978					
1979	59 200				
1980					
1981	-130				
1982	495				
1983	-71				
1984	-68				
1985	-111				
1986	500				
1987	500				
1988					
1989	669 495				
1990	500	-	65		
1991					
1992	1500				
1993	669 495				
1994	650				

[1]These represent the plants to be added or removed under the new time schedule in place of the original schedule (1976-1985).

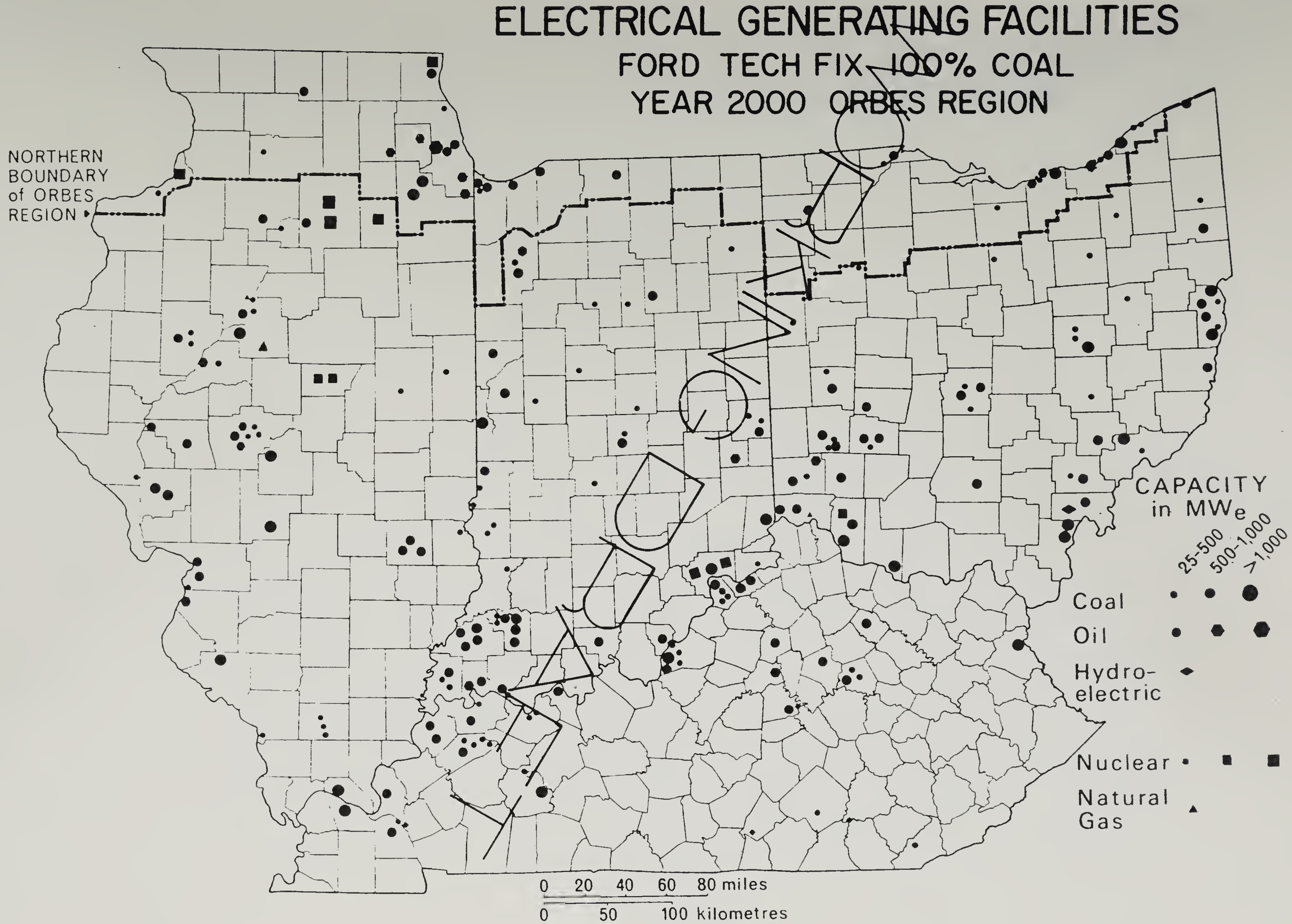
(continued)

TABLE C-11 (continued)
NEW DATES FOR BRINGING PLANTS ON-LINE: 1976-1994[1]

ORBES OHIO

Year	Coal	Nuc	Oil	Gas	Hydro	Unknown
1976	375	-	-2			
1977	615	-	-	-111	40	
1978				-108		
1979						-130
1980	-64 557					-53
1981						
1982						
1983	375					
1984						
1985						
1986						
1987	661	878				
1988	375					
1989						
1990						
1991	661 375					
1992	615					
1993						

[1]These represent the plants to be added or removed under the new time schedule in place of the original schedule (1976-1985).



ELECTRICAL GENERATING FACILITIES
FORD TECH FIX 100% COAL
YEAR 2000 ORBES REGION
NORTHERN BOUNDARY of ORBES REGION
CAPACITY in MWe
25-500
500-1,000
>1,000
Coal
Oil
Hydro-electric
Nuclear
Natural Gas
0 20 40 60 80 miles
0 50 100 kilometres

FIGURE C-6

ELECTRICAL GENERATING FACILITIES
FORD TECH FIX 100% NUCLEAR
YEAR 2000 ORBES REGION

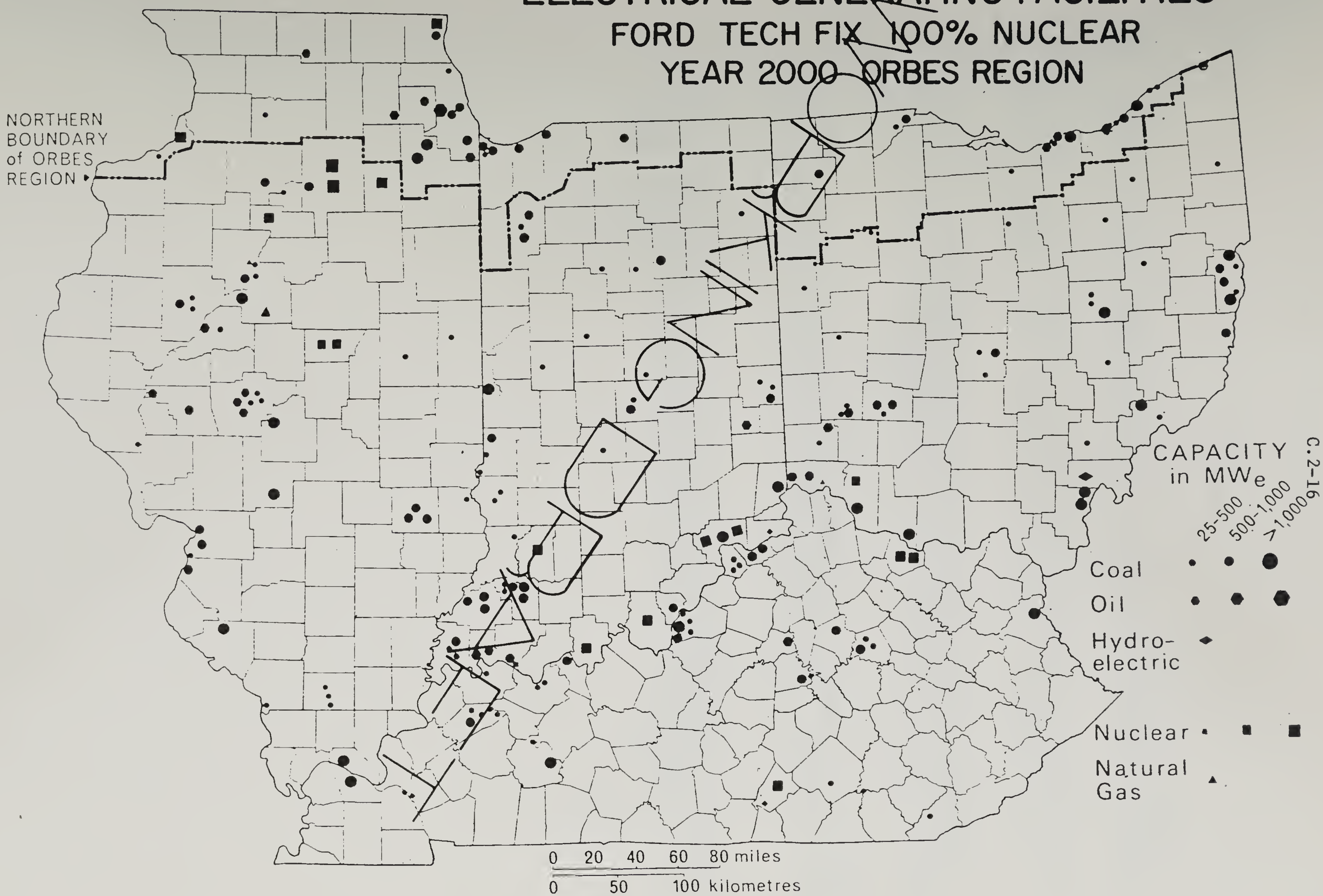


FIGURE C-7

REFERENCES

1. Dupree, W. G., Jr., and Corsentino, . S. United States Energy Through the Year 2000 (Revised). Washington, DC: Bureau of Mines, Department of the Interior, December]975.

2. A Time to Choose America's Energy Future, Chapter 3, Final Report, Ford Foundation. The Energy Policy Projects, Cambridge, Mass.: Ballinger, 1974.

3. Electrical Generation Capability in Illinois, Indiana, Kentucky and Ohio and in the ORBES Region - 1975 and 1985. Chicago: Energy Resources Center, University of Illinois at Chicago Circle, October 1976.

4. Forecasts of Electrical Power and Energy Requirements for the ORBES States and ORBES Subregions Through the Year 2000. Chicago: Energy Resources Center, University of Illinois at Chicago Circle, December 10, 1976.

5. Locations of Electrical Generation Units Anticipated to be Constructed Within the Illinois Section of the ORBES Region, 1985-2000. Chicago: Energy Resources Center, University of Illinois at Chicago Circle, November 1976.

D. MINI-TECHNOLOGY ASSESSMENT OF REGIONAL TECHNOLOGY CONFIGURATIONS

D.0 MINI-TECHNOLOGY ASSESSMENT OF REGIONAL TECHNOLOGY CONFIGURATIONS

D.1 METHODOLOGICAL APPROACH

The methods used in comprehensive technology assessments such as the ORBES project must permit the team to analyze the relevant relationships between technological deployment and their associated impacts, and to evaluate the direction and intensity of these relationships (1,2). In particular, four steps are important:

1. Inventory the relevant impact.
2. Distinguish between levels of impacts.
3. Trace the linkages between consequences over time and space.
4. Provide information, insight and optional strategies to decision makers.

The process of a comprehensive TA is complex. Consequently, an efficient system of bookkeeping is necessary to keep track of the variables and their functional relationships and to encourage integration among members of an interdisciplinary team. Structural models, which are represented by interaction matrices, help to meet these requirements (3,4,5 and 6).

The present preliminary impact assessment follows a procedure which is based upon information gathered from a set of interaction matrices. Three steps are involved, each corresponding to an activity in the methodological framework outlined above. The emphasis here is upon a qualitative assessment of significant impacts of energy system functions, the majority of which is associated with impacts upon the physical and social environment.

D.1.1 IDENTIFICATION AND CHARACTERIZATION OF SIGNIFICANT IMPACTS

The identification and characterization of significant impacts is the first step in an impact assessment. The impacts which have been identified

by the team as significant are shown on a master interaction matrix in which the six basic functions associated with coal- and nuclear-based energy conversion technologies are the components of the vertical axis, and fourteen general impact categories are the components of the horizontal axis (Table D.1-1). The impacts are those which the assessment team expects to occur by the year 2000.

The nature of each impact, or interaction, as described in functional terms (e.g., "decrease in agricultural land," "increase in acid drainage," or "climatic change") and characterized according to: 1) probability of occurrence; 2) duration; 3) intensity; and 4) geographical scale.

The significant impacts include those impacts that are most likely to occur, and those that have the longest duration and intensity. Most of them are the direct consequence of one or more of the physical processes associated with technological functions of the energy system.

TABLE D.1-1

MASTER INTERACTION MATRIX OF ENERGY FUNCTIONS AND IMPACT CATEGORIES

Energy Functions \ Impact Categories	Land Use	Material & Capital Resources	Transportation	Water Use	Air Quality & Climatology	Water Quality & Hydrology	Land Quality & Geomorphology	Biological ecological	Employment	Demographic	Economic	Social	Political	Public Health
1. Plant Construction	X	X									X			
2. Extraction	X	X		X	X	X	X	X		X		X		X
Surface Mining	X	X			X	X	X	X				X		X
Deep Mining	X	X		X	X	X	X	X				X		X
3. Processing	X	X	X	X	X		X	X				X		X
Cleaning & Milling	X	X	X	X	X		X							
Concentrating														
Enriching	X	X			X		X							
Fabrication	X	X	X											
4. Transportation	X	X	X	X	X	X	X					X		X
Raw Materials	X	X	X		X	X	X							
Fuel	X	X	X											
Electricity	X													
Waste		X	X			X								
5. Conversion	X	X		X	X	X	X	X		X	X	X		X
Electrical Generation		X		X	X	X	X	X		X		X		X
Low BTU Gasification	X				X	X								
Hi BTU Gasification	X				X	X								
6. Waste Disposal	X	X			X	X	X	X				X		X
Thermal					X	X		X				X		X
Ash (Coal & Nuclear)	X			X	X	X	X					X		X
Scrubbers	X	X			X							X		X
7. Utilization	X					X	X			X		X		X
Industrial												X		X
Commercial												X		X
Residential												X		X
Transportation														X

D.1.2 IDENTIFICATION OF PARTIES AT INTEREST

Parties at interest are the various individuals and groups affected in some manner by the various energy functions. In an objective sense, most people living in the same community will share all the identified impacts. All persons living within fall-out range of smokestacks will share whatever degree of public health damage is created by their emissions. However, because of their particular circumstances different individuals will be affected to different degrees. Asthma sufferers will be objectively affected to a greater degree by increases in air pollutants than others in the community. Nevertheless, if an accurate measure of each of the impacts were available, it would be possible to measure the objective degree of impact felt by each member of a community, as well as the cumulative impact for the entire collectivity.

In addition to such objective impacts, subjective perceptions of impacts are also important. Parties at interest are also identifiable by their perception of various impacts which increased energy conversion facilities have on them. Some will perceive the impact in its "objective" terms; others will either fail to perceive an impact at all, or perceive that one exists which has no objective measure. These several types of impacts are categorized in Figure D.1-1 where + indicates that an impact exists (either objectively or perceptually) and 0 indicates that it does not.

It may be possible to identify specific interests in particular communities and predict their reaction to the siting of a conversion facility near them. However, most people in most communities play multiple roles,

OBJECTIVE IMPACT	SUBJECTIVELY PERCEIVED IMPACT +	0
+	++	+0
0	0+	00

FIGURE D.1-1 OBJECTIVE IMPACTS VERSUS SUBJECTIVELY PERCEIVED IMPACTS

and some of these roles will cause conflict in reactions to the impacts or such facilities. For example, a retail businessman who increases his income from increased business may also be an asthma sufferer who objects to dirtier air. Table D.1-2 identifies general categories of individuals who might be expected to respond in some manner, either negatively or positively, to increased energy conversion facilities in ORBES. A single individual may be represented several times in this list, and some citizens may not appear in any category. Consequently, we should never lose sight of the collective interest of all residents of communities, because the reactions of some of these individuals may not be predictable regardless of how comprehensive our list of interests becomes.

The first section of the list identifies economic categories because one logical way of reacting is according to one's economic role. However, a second type of category is also represented: noneconomic roles. It is likely that a person who is represented in the first half of the table

(a business executive, laborer, farmer) may also be represented among other groups (a recreationist, environmentalist, church member, etc.).

In addition to identifying the categories of people, interested organizations which may or may not exist in any given community, and may or may not arise during the projected period have been identified. These organizations are viewed as representing the interests of the constituents, but it is also possible that they may generate responses separate from their memberships. In some cases, as for example the League of Women Voters or churches, it is not possible to identify their constituents except in terms of the organization.

TABLE D.1-2

PARTIES AT INTEREST

ECONOMIC GROUPS & ORGANIZATIONS

Industrialists
- Energy conversion companies
- Industrial consumers of energy
  - High-energy consumption industries
  - Lower-energy consumption industries
  - Trade Associations
  - National Association of Manufacturers

Commerce
- Retail trade
  - Small, independent businesses
  - Large, chain/franchise operations
  - Chamber of Commerce
  - Junior Chamber of Commerce

Labor
- Miners
- Construction workers
- Transportation worders
- Relevant unions

Agriculture
- Corporate farmers
- Family farmers
- Tenant farmers
- Farm Bureau
- National Farmers Organization
- Grange

Recreation Industry
- Resort owners
- Marina operations
- Trade Association

Professional Service
- Health & A.M.A.
- Law & A.B.A.
- Education & N.E.A.
- Media

Real Estate Industry
- Trade Association

Landholders
- Absentee
- Income property holders
- Residents
  - Historic
  - Newcomers

NONECONOMIC GROUPS

Environmentalists
- Audubon Society
- Sierra Club
- National Resources Defense Council

Recreationists
- Rod and Gun Clubs
- Izaak Walton League

General
- Ad Hoc groups
  - In favor of development
  - In favor of conservation
  - Churches
  - League of Women Voters
  - Kiwanis
  - Moose
  - Elk
  - Save the Valley

D.1.3 POTENTIALLY RESPONSIVE AGENCIES

Similarly, public agencies such as the Soil Conservation Service or public health agencies in a community may represent a constituency, but may also raise issues of their own. Consequently, they have been identified separately. These same agencies will play at least two roles in public policy. They will have reactions to specific impacts from the development of additional conversion facilities. They will also be the agencies to which other role-players in the system will turn when making their demands for change or amelioration of impacts. Thus, they constitute the potentially responsive agencies described in the following sections of the report. A partial list is shown in Table D.1-3.

TABLE D.1-3

POTENTIALLY RESPONSIVE AGENCIES

*Public Agencies (Federal, State and Local)

- General elective/professional managers
  - Municipal
    - Mayors
    - Councils
    - Managers
  - County
    - Boards of supervisors
    - Zoning board members
    - Plan commissions
    - State
- Functional officials
  - Sanitation districts
  - Solid waste disposal regions
  - Pollution control agencies
  - Educational
  - Cultural
  - Public health
  - Welfare/unemployment
  - Fire protection
  - Law enforcement
    - Police
    - Prosecutors/Public defenders
    - Judges
  - Agriculture
  - Recreation
    - Park districts
    - Fish and wildlife
  - Economic development
  - Labor/management
  - Water resources
  - Transportation authorities

*These agencies are both parties at interest and potentially responsive agencies. Examples of specific agencies are given for the significant impacts identified in the following section of this report, in which the significant impacts of the RTCs are assessed.

D.1.4 IDENTIFICATION OF POLICY GOALS AND OPTIONS

It is necessary to break down the discussion of any public policy into two dimensions. The first concerns the policy goals which must be chosen by the polity; the second deals with the various methods/options by which decision makers may seek to achieve those goals. It is not the purpose of this project to select policy goals for society. However, in order to identify policy options, it is necessary to spell out what the goals may be and how they interact with policy options.

Policy goals can be divided into several levels. The most general level concerns the size of demand/supply of energy in the Ohio River Basin. Logical options range from net decrease in supply/demand for energy to unlimited growth in demand/supply. Task 1 has defined basically two futures to be assessed in Task 2: very large increases in energy supply/demand and moderate increases in supply/demand. Both of these goals are based on presumptions of increased population, increased industrial production, increased per capita consumption of energy in the ORBES region, and, possibly, increased export of energy from the region. There is, however, no reason to restrict decision makers to these presumptions.

Given the general goal of increasing energy supply/demand, two secondary policy goals may be addressed: conservation in energy use and increased number of energy conversion facilities in the ORBES region. Obviously, supply/demand for energy in the ORBES region will be affected by supply/demand in regions exogenous to ORBES. However, for purposes of this study, these variables will not be considered.

In order to attain the secondary policy goals (reduced growth in the demand for energy and increased number of energy conversion facilities),

several different policy options are available. These policy options may be divided into two categories: economic controls and direct regulation. These types of policy options are depicted in Table D.1-4, and some examples are given in each cell, but these examples are meant to be neither comprehensive nor mutually exclusive. For example, if some degree of the policy goal of energy conservation is selected, two main types of economic controls are available: expenditure of public funds and manipulation of revenue-raising devices. Public funds could be used on research to develop nontraditional energy systems using sources that are replenishable. The purpose would be to reduce reliance upon and conserve fossil fuels. In addition, by direct regulation consumers could also be given tax incentives to invest in such alternate energy systems.

Direct control of energy prices by public bodies is considered to be direct regulation of utilities rather than economic control, because the company is under strict regulations to comply. The impacts which such direct price controls have on the consumer, however, are economic or indirect, because the energy user is expected to respond to increased prices by reducing his demand for the supply, but he is under no directive to do so. A more direct regulation of his behavior would be rationing of energy to individual types of consumers or restricting the use of energy for particular purposes. For example, regulations could be made to show preference for residential heating during periods of low supply and/or low temperatures.

Both secondary goals of reduced demand and increased supply have impacts. They are characterized in general in Table D.1-5. Once the impacts from secondary goals have been identified, it is possible to

continue to the next level of policy goals and consider ameliorative goals. In the case of reduced demand for energy, for example, it is speculated that one economic impact would be unemployment in energy-intensive sectors of the economy. One obvious ameliorative goal for this impact, therefore, would be increased employment in nonenergy-intensive sectors of the economy. The policy options available to public decision-making bodies to reach this goal would be all the economic and direct regulatory methods discussed in Table D.1-4.

Impacts from the policy goal of increased conversion facilities have been identified in section D.2. Ameliorative goals can be identified for each of these impacts, but these are dependent on goal-setting decisions by policymakers. It is not the purpose of this study to choose among them, but to lay out some of the logical possibilities. One possible ameliorative goal for an environmental impact would be to abate pollutants. If this goal is chosen, the same categories of policy options are available to decision makers. Examples of these are given in Table D.1-6. In addition, it is necessary to identify the governmental level at which these policy options may be adopted. All three levels of government could potentially use all policy options, although in some cases there is a greater likelihood of one of the levels adopting that option. For example, the federal government is more likely to be able to afford to finance research on solar power than are states and localities. However, that does not preclude the latter from using its funds in this manner. States are more likely to use their planning authority to control the siting of specific energy conversion plants than are localities or the federal government. Zoning laws do not always cover energy conversion facilities, and there is presently no

federal land-use planning law. This is not to say, however, that local zoning authorities are precluded from ever using their authority in this way, nor is the U.S. Congress prevented by anything other than the political decision-making process from formulating a national land-use planning law.

In addition, each policy option presently in use is the enforcement responsibility of some specified agency (or agencies) of government. For example, the Nuclear Regulatory Commission, the Federal Power Commission, the Environmental Protection Agency, etc., can be identified as agencies with regulatory responsibilities. Also such agencies as ERDA and NSF are agencies charged with roles to utilize research funds and to develop new technologies for energy conversion facilities. Other agencies may presently have such responsibilities and many more may receive such responsibility in the future.

TABLE D.1-4

TYPES OF POLICY GOALS AND OPTIONS

	POLICY GOALS	
Policy Options (Economic)	Reduced Demand/ Conservation	Increased Supply/ More Energy Conversion
Public expenditures for research and development and facilities	Development of non-traditional energy systems for use in home and industry	Gasification of coal Liquid metal fast breeder Solar
Public revenues taxation: Rates/credits Increase-decrease Depreciation of facilities	Tax credit for energy conserving in the home and industry	Preference taxation for particular energy forms Tax credits/rapid depreciation for energy conversion facilities
Policy Options (Direct Regulation)		
Price controls	Higher prices to reduce demand	Higher prices to induce development of more energy sources
Rate regulation	Preferential price for users with less elasticity of demand	Preferential pricing for preferred energy forms and/or users
	Load levelling pricing (peak load - higher)	

TABLE D.1-5

IMPACTS, GOALS, AND OPTIONS

Policy Goals	Impact from Policy Goals	Ameliorative Goals	Policy Options
Reduced demand/ conservation	Increased unemployment in energy-intensive economic sector	Increased employment in non-energy-intensive economic sector	See Table D.1-4
Increased supply/ more energy conversion	Demographic Economic Social Environmental Public Health Political	Control increased cost-of-living Control conflict Abate pollutants Prevent deterioration	See Table D.1-4

TABLE D.1-6

POSSIBLE POLICY OPTIONS FOR ONE AMELIORATIVE GOAL

Ameliorative Goal	Policy Options/Tools	Governmental Level	Type of Agency to Implement
Abate Pollutants	<u>Economic</u>:		Research: ERDA, NSF, NIH, EPA
	R & D for new technology	Primary federal/state	Tax: IRS, state revenue, local assessors
	Tax incentives to apply present technology (effluent/emission charges)	Federal/state/local	Charge: Federal EPA, STATE EPA
	Charge for not applying present technology (effluent/emission charges)	Federal/state/local	
	<u>Direct Regulation:</u>		
	Standard setting	Federal/state	EPA
	Permit Issuance	Federal/state	EPA
	Monitoring permit use	Federal/state	EPA
	Violation prosecution	Federal/state	EPA
	Penalty application	Federal/state	Courts

REFERENCES

1. Berg, M. R., Chen, K. and Zissis, G. J., "Methodologies in Perspective," in Perspectives on Technology Assessment. Edited by S. R. Arnstein A. H. Christakis. Jerusalem: Science and Technology Publishers, 1975.

2. Hetman, F., Society and Assessment of Technology. Paris: Organization for Economic Co-operation and Development. 1973.

3. Kawamura, K. and Christakis, A. N. "The Role of Structural Modeling in Technology Assessment," paper presented for the Second International Congress on Technology Assessment. Ann Arbor, Michigan, October 24-28, 1976.

4. Kawamura, K. and Christakis, A. N., "The Role of Structural Modeling in Technology Assessment," paper prepared for the Second International Contress on Technology Assessment, Ann Arbor, Michigan, October 24-28, 1976.

5. McLean, M. "Does Cross-Impact Analysis Have a Future?," Futures, Vol. 8, no. 4 (August, 1976), pp. 345-349.

6. McLean, M., and Shepherd, P., "The Importance of Model Structure," Futures, Vol. 8, No. 1 (February, 1976), pp. 40-51.

D.2 OVERVIEW OF ASSESSMENT PROCEDURE

Figure D.2-1 provides a schematic view of the flow of the ORBES assessment process. After characterizing the ways in which power facilities might be deployed (the 4 scenarios), the physical, environmental, social and political impacts are identified and assessed to the year 2000.

Future power plant deployment is assessed as that deployment's physical impacts upon land, materials, transportation and water. In turn, physical impacts are translated into impacts upon environmental quality. In parallel, social, economic, and political assessments are being conducted to determine the range of impacts upon the population of the region. The two stems of the analysis are combined in a determination of policy alternatives to achieve acceptable standards of public health and well being.

The impact assessment information in this preliminary report is presented in a series of summary tables, one for each general impact category. Each summary table is preceded by a narrative describing the general types of impacts to be considered in the category and comparing, where possible, the impacts expected to result from the 4 scenarios. The most significant impacts in each impact category are listed, by energy function, in the left-hand column and then characterized (by symbols) separately for the new facilities which are planned under the differing projects.

The differences in impacts between the scenarios are considered separately in order to determine the relative importance of fuel mix and siting patterns in impact change. After identifying and comparing impacts, the tables also identify impacted parties, how they are impacted, what the issues are, the policy options, what agencies might deal with the problem and what the likely results might be.

The information contained in these tables has the following restrictions:

1. The identification and characterization of the impacts are qualitative judgements based upon existing public information.

2. Most of the impacts are first-order consequences of the energy system functions, and are concentrated in the physical and biological impact categories.

3. The assessment is regional in scale, and hence considers the aggregate impacts which are associated with the type and geographical distribution of energy conversion technologies of the year 2000.

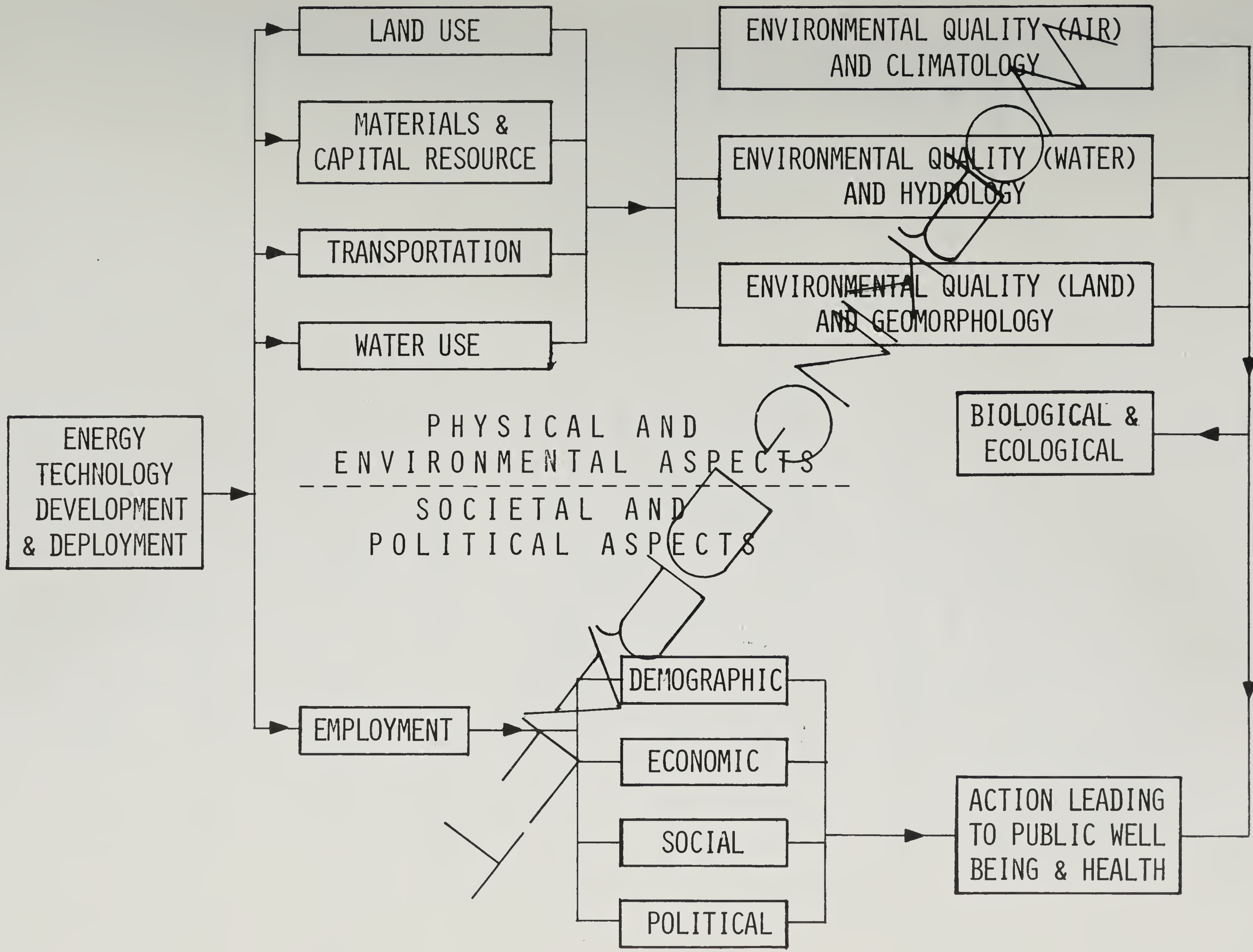


Figure D.2-1
FLOW OF ORBES ASSESSMENT PROCESS

D.3 LAND USE IMPACTS

The primary impacts of coal- and nuclear-related energy functions on land use result from the conversion of land from present uses to energy-related uses. Land areas devoted to extraction, processing, conversion, waste disposal, transportation of materials and electricity, as well as land developed in the utilization of the electricity produced, fall within the category of primary land use impacts. These impacts are summarized, characterized, and compared for each Regional Technology Configuration (RTC) in Table D.3-1.

It is evident from the table that the Bureau of Mines RTCs will have more severe land use impacts than the Tech Fix RTCs. This is true for each of the functions. The differences are a direct result of the greater amount of electrical power required under the BOM RTCs. A more detailed comparison of the RTCs and their constituent functions can be achieved by estimation of the amount of land involved. This has been done for the BOM RTCs and will be done for the Tech Fix RTCs as soon as an acceptable time phasing for the Tech Fix power plants is agreed upon.

Table D.3-2 presents a comparison of selected land use requirements for the two BOM RTCs. Only those functions likely to result in significant land use changes within the ORBES region are included. Thus, uranium extraction is not treated since it is extremely unlikely that the low grade uranium deposits of the region will be developed before the year 2000. Other functions, such as material transportation, have not been included because their estimation requires site specific analysis at a level of detail smaller than the county level siting specified in the RTCs. Land use changes resulting from utilization of electrical power have not been included due to the difficulty involved in estimating the magnitude of

TABLE D.3-2

COMPARISON OF LAND USE REQUIREMENTS FOR BOM RTCs*

(IN SQUARE MILES)

FUNCTIONS	1976-1985	1986-2000 BOM 80-20	1986-2000 BOM 50-50	1976-2000 BOM 80-20	1976-2000 BOM 50-50
COAL EXTRACTION	727	3,472	2,850	4,199	3,577
SURFACE	374	1,213	1,030	1,586	1,404
DEEP	353	2,259	1,820	2,612	2,173
COAL PROCESSING	11	61	38	72	48
CONVERSION	53	275	304	327	357
COAL	36	213	130	249	166
NUCLEAR	17	62	174	78	190
ELECTRICAL TRANSMISSION	18	64	65	82	82
TOTAL	798	3,810	3,218	4,608	4,016

* Totals may not agree due to rounding error.

such changes. Coal gasification plants are not included because the size of the low Btu plants in still under discussion.

The values in Table D.3-2 represent the cumulative land requirements (in square miles) for each of the BOM RTCs over the pertinent time periods. Right justified figures represent totals for functions and left justified figures represent totals for subfunctions. Meaningful interpretation of these figures is dependent upon knowledge of the assumptions involved in each estimation. These assumptions are given below.

Coal Extraction

3×10^6 tons of coal/year for each 1,000 MWe coal-fired generating unit operating at full capacity (1, p. 1d-2b; 2, p. 346; 3, p. 130).

1/3 of utility coal used in ORBES region is imported from outside ORBES region until 1985 (agreed by Il Task II Team).

1985 amount of coal imported into ORBES region remains constant until 2000 (agreed by IL Task II Team).

Conversion facilities come on line in a linear fashion for entire period (1976-2000) (agreed by IL Task II Team).

50% strip, 50% underground extraction of ORBES coal in 1976 (agreed by IL Task II Team).

30% strip, 70% underground extraction of ORBES coal in 1985 (agreed by IL Task II Team).

15% strip, 85% underground extraction of ORBES coal in 2000 (agreed by IL Task II Team).

Surface

?

141 acre/10^6

484.5 acre/10^6 tons coal disturbed by surface extraction in ORBES (2, p. 346).

Underground

?

226 acre/10^6

285.9 acres/10^6 tons coal disturbed by underground extraction (includes area subject to subsidence) in ORBES (2, p. 346).

Uranium Extraction

Unlikely to occur in region before 2000.

Coal Processing

300 acres/1,000 MWe —one such site required for each 1,000 MWe generating unit located at mining site and therefore included in extraction land (2, p. 246).

Conversion

20% of the 1,000 MWe units will utilize cooling ponds.

40% will utilize natural draft cooling towers.

40% will utilize mechanical draft cooling towers (agreed by IL Task II Team).

Coal

640 acres/1,000 MWe (exclusive of cooling ponds) (personal communication with Commonwealth Edison).

2,000 acres/1,000 MWe for cooling pond (3, p. 124).

Nuclear

980 acres/1,000 MWe (exclusive of cooling pond) (personnel communication with Commonwealth Edison).

3,000 acres/1,000 MWe for cooling pond (3, p. 124).

Electrical Transmission

200 foot right-of-way.

Straight line connection to nearest 189 kv or greater line.

Minimum of 10 miles needed to connect into grid.

Of the land use impacts listed in the table, clearly coal extraction is the most serious. Out of a total of 4,608 square miles affected under the

BOM 80-20 RTC, 4,199 square miles, or about 91%, is due to coal extraction. The total listed for the BOM 80-20 RTC represents about 3% of the land area of the ORBES region. Comparable figures for the BOM 50-50 RTC are somewhat lower due to emphasis on coal development within the region in the BOM 80-20 RTC as opposed to a greater degree of uranium development outside the ORBES region under the BOM 50-50 RTC. The figures for extraction may be inflated due to the assumption that the coal plants will operate at full capacity and the fact that all land theoretically subject to subsidence is included in the deep extraction subtotal. These high estimates may be compensated for by the exclusion of the coal required to operate the coal gasification plants.

The BOM 50-50 RTC requires more land than the BOM 80-20 RTC for both conversion sites and transmission lines. Nuclear plants require more land at the generating site for two reasons: 1) a buffer zone is required for safety purposes; and 2) larger cooling ponds are required to dissipate waste heat. It is important to keep in mind also that land occupied by nuclear reactors will be taken out of production for many hundreds of years after the useful life of the plant due to radioactive contamination of the site. This is not the case for coal-fired plants. More land is required for transmission lines from nuclear plants because population density constraints near nuclear sites require that they be located further from load centers. For both RTCs, the estimated land requirements for transmission lines are extremely low. It was assumed that only one connection into the existing grid was required, although in actual practice, multiple grid connections are necessary to ensure the reliability of the system. It was further assumed that nearby existing transmission lines could carry the added capacity of a new generating station. This is clearly not the case in many instances. Land use requirements for transmission lines should be expanded by at least a factor of three to be more realistic. Much additional site specific information is required before

accurate estimates of transmission line requirements can be calculated.

Although not included in Table D.3-1, both BOM RTCs will require extensive amounts of land at the utilization end of the function spectrum. The BOM scenario is based on the premise that population and per capita consumption of electrical energy will increase substantially. Even after discounting for the substitution of electrical energy for oil and natural gas, the scenario implies a greater population with a higher standard of living. This indicates a substantial increase in land devoted to industrial, commercial, residential and transportation uses. Urbanization impacts will extend beyond the ORBES region, at least to the parts of Illinois, Indiana and Ohio not in the region. Differences between the BOM RTCs due to utilization impacts on land use are negligible.

The major impact of the land use changes indicated above will likely be on land which is currently used for agricultural purposes (including privately owned forest land). This preliminary conclusion is based on the fact that most of the ORBES region is currently used for agriculture and that the sites suitable for energy and urban development are also suitable for, and are currently used for, agricultural purposes.

As mentioned above, land requirements for the Tech Fix RTCs have not yet been estimated. However, it is safe to conclude that, based on the impacts listed and the assumptions concerning land requirements, the Tech Fix RTCs will require substantially less land use change than the BOM RTCs. The comparison will be quantified in a future report.

In addition to the primary impacts discussed above, second- and higher-order impacts on land use may prove to be significant. For example, it is reasonable to assume an influx of workers and their families into areas where energy development will take place (see section on demography). These workers will require additional housing and services, and therefore land use changes

are inevitable. It is also conceivable that food prices may rise faster than other commodities due to significant reductions in the amount of prime agricultural land.

A further purpose of this report is to go beyond the identification and characterization of impacts by identifying impacted parties and exploring institutional arrangements potentially capable of reducing the severity of impacts. A tabular representation of this effort is presented in Table D.3-1. The parties interested in land use can be categorized as those having primarily an economic interest (business, farmers, landowners and the real estate industry) and those having primarily a non-economic interest (recreationists, environmentalists and ad hoc groups).

The relevant issues revolve around the questions of: 1) government intervention in the form of zoning or land use planning; and 2) government regulation of land restoration. The first issue encompasses the option of limiting energy development to areas most suitable for energy development or conversely, excluding energy development from areas most suitable for other uses. The second issue includes the option of returning energy development land to productive use by requiring land restoration. These policy options have the potential for reducing impact severity to an acceptable level if implemented by the potentially responsive institutions.

REFERENCES

1. ORBES Task I Report, October 18, 1976.

2. Wilson, R. and Jones, W., Energy, Ecology, and the Environment, New York: Academic Press, Inc., 1974.

3. MacFarland, D., et al., Power Facility Siting in the State of Illinois, Part II - Environmental Impacts of Large Energy Conversion Facilities, Chicago, Illinois: Illinois Institute for Environmental Quality, 1975.

TABLE A - LAND USE - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION									
COAL									
Surface	Reduced acreage in agriculture & forest. Increased acreage in disturbed, rural non-farm and urban/industrial/suburb.	AC,(S,L),SV, LO	AC,(S,L),SV, LO	AC,(S,L),SV, LO	1	AC,(S,L),SV, LO	VU,(S,L),SV,LO	3	BOM
Underground	As above	As above	As above	As above	1	As above	As above	3	BOM
NUCLEAR									
Exploration	As above	VU,S,I, LO	VU,S,I,LO	P,S,I,LO	2	AI,S,I,LO	P,S,I,LO	4	BOM
Surface	As above	VU,L,SV, LO	VU,L,SV,LO	P,L,SV,LO	2	AI,L,SV,LO	P,L,SV,LO	4	BOM
Underground	As above	As above	As above	As above	2	As above	As above	4	BOM
PROCESSING									
COAL									
All Subfunctions	As above	AC,L,MD, LO	AC,L,MD,LO	AC,L,MD,LO	1	AC,L,MD,LO	AC,L,MD,LO	3	BOM
NUCLEAR									
Milling	As above	VU,L,MD, LO	VU,L,MD,LO	P,L,MD,LO	2	AI,L,MD,LO	P,L,MD,LO	4	BOM
Enriching	As above	AC,L,MD, LO	AC,L,MD,LO	AC,L,MD,LO	2	AC,L,MD,LO	AC,L,MD,LO	4	BOM
Fabricating	As above	P,L,MD, LO	P,L,MD,LO	P,L,MD,LO	2	VU,L,MD,LO	P,L,MD,LO	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - LAND USE - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION COAL AND NUCLEAR All Subfunctions	Reduced acreage in agriculture & forest. Increased acreage in disturbed, rural non-farm, and urban/industrial/suburban	Business Farmers Recreation Landowners Environmentalists Real estate industry Ad hoc interest groups	M, + or - SV, - M, + or - SV, - SV, - M, + or - M, -	1- Identification of land areas most appropriate for conversion to energy-related use 2- Land restoration	Zoning, comprehensive land use planning, strip mine legislation, bonding authority for land restoration	Federal: Courts, Congress State: Courts, Legislation Local: Court Planning & Zoning Bd.	
PROCESSING COAL All Subfunctions	As above	As above	As above	As (1) above	Zoning, comprehensive land use planning	As above	
NUCLEAR All Subfunctions	As above	As above	As above	As (1) above	As above	As above plus NRC, Regulatory Comm.	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - LAND USE - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
CONVERSION									
COAL									
Electrical Generation	Reduced acreage in agriculture & forest. Increased acreage in disturbed, rural non-farm and urban/industrial/suburb.	AC,L,SV,LO	AC,L,SV,LO	AC,L,SV,LO	1	AC,L,MD,LO	AC,L,MD,LO	3	BOM
Low BTU Gasification	As above	N	AC,L,MD,LO	AC,L,MD,LO	N	N	N	N	BOM
High BTU Gasification	As above	N	As above	As above	N	N	N	N	BOM
NUCLEAR									
Electrical Generation	As above	AC,L,SV,LO	AC,L,SV,LO	AC,L,SV,LO	2	N	AC,L,SV,LO	4	BOM
TRANSPORTATION									
COAL									
Processed	As above	P,L,I,LO	P,L,I,LO	P,L,I,LO	1	P,L,I,LO	VU,L,I,LO	3	BOM
Raw Material	As above	As above	As above	As above	1	As above	As above	3	BOM
Conversion Products	As above	N	P,L,MD,LO	P,L,MD,LO	N	N	N	N	BOM
Electricity	As above	AC,L,SV,MC	AC,L,SV,MC	AC,L,SV,MC	1	AC,L,SV,MC	VU,L,SV,MC	3	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - LAND USE - 4

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
CONVERSION COAL AND NUCLEAR All Subfunctions	Reduced acreage in agriculture & forest. Increased acreage in disturbed, rural non-farm, and urban/industrial/suburban	Business Farmers Recreation Landowners Environmentalists Real estate industry Ad hoc interest groups	M, + or - SV, - M, + or - SV, - SV, - M, + or - M, -	Identification of areas most appropriate for conversion to energy-related uses	Zoning, comprehensive land use planning	Federal: Courts, Congress, Regulatory Agency State: Courts, Legislature Regulatory Agency Local: Courts, Planning & Zoning Bd.	
TRANSPORTATION COAL AND NUCLEAR All Subfunctions	As above	As above	As above	Identification of areas most appropriate for conversion to energy-related transportation uses	Land use planning	As above	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - LAND USE - 5

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
NUCLEAR									
Raw Material	Reduced acreage in agriculture & forest. Increased acreage in disturbed, rural non-farm and urban/industrial/suburb.	P,L,I, LO	P,L,I,LO	P,L,I,LO	2	VU,L,I,LO	P,L,I,LO	4	BOM
Fuel	As above	As above	As above	As above	2	As above	As above	4	BOM
Electricity	As above	AC,L, SV,MC	AC,L,SV,MC	AC,L,SV,MC	2	VU,L,SV,LO	AC,L,SV,LO	4	BOM
Water	As above	VU,L, I,LO	VU,L,I,LO	P,L,I,LO	2	VU,L,I,LO	P,L,I,LO	4	BOM
WASTE DISPOSAL COAL									
Scrubber Sludge	As above	AC,L, SV,LO	AC,L,SV,LO	AC,L,SV,LO	1	AC,L,SV,LO	VL,L,SV,LO	3	BOM
Ash	As above	As above	As above	As above	1	As above	As above	3	BOM
Non-energy By-products	As above	As above	As above	As above	1	As above	As above	3	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - LAND USE - 6

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
WASTE DISPOSAL COAL AND NUCLEAR All Subfunctions	Reduced acreage in agriculture & forest. Increased acreage in disturbed, rural non-farm, and urban/industrial/suburban	Business Farmers Recreation Landowners Environmentalists Real estate industry Ad hoc interest groups	M, + or - SV, - M, + or - SV, - SV, - M, + or - M, -	Identification of areas most appropriate for waste disposal	Zoning, land use planning	Federal: Courts, Congress, Regulatory Agency State: Courts, Legislature Regulatory Agency Local: Courts, Planning & Zoning Bd.	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - LAND USE - 7

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
NUCLEAR Dilution & on-site storage	Reduced acreage in agriculture & forest. Increased acreage in disturbed, rural non-farm and urban/industrial/suburb.	AC,L, I,LO	AC,L,I,LO	AC,L,I,LO	2	AC,L,I,LO	AC,L,I,LO	4	BOM
Permanent Storage	As above	AC,L, MD,LO	AC,L,MD,LO	AC,L,MD,LO	2	AC,L,MD,LO	AC,L,MD,LO	4	BOM
Reprocessing	As above	AI,L, MD,LO	VU,L,MD,LO	P,L,MD,LO	2	AI,L,MD,LO	P,L,MD,LO	4	BOM
UTILIZATION COAL Electrical Generation	As above	N	AC,L,I,LO	AC,L,I,LO	N	N	N	N	BOM
All other Subfunctions	As above	AC,L, SV,N	AC,L,SV,N	AC,L,SV,N	N	VU,L,SV,N	VU,L,SV,N	N	BOM
NUCLEAR All Subfunctions	As above	As above	As above	As above	N	As above	As above	N	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - LAND USE - 8

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
UTILIZATION COAL AND NUCLEAR All Subfunctions	Reduced acreage in agriculture & forest. Increased acreage in disturbed, rural non-farm, and urban/industrial/suburban	All parties are potentially interested	Depends on parties' perception of impacts (SV to I), (+ to -)	Evaluation of desirability of regulation or non-regulation of development resulting from utilization of electricity produced under RTC's	Zoning, comprehensive land use planning	Federal: Courts, Congress State: Courts, Legislation Local: Courts, Planning & Zoning Bd.	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

D.4 MATERIAL & CAPITAL RESOURCES IMPACTS

The major impact of the two Bureau of Mines RTCs on material resources is the reduction of non-replenishable material reserves such as coal, oil, gas, uranium, ferrous material, non-ferrous ores, and construction materials. The two Ford Tech Fix RTCs provide a much lesser impact on material resources than BOM. The increased use of coal as an energy source, of course, reduces that resource at a more rapid rate. As time passes, current air standards legislation will relegate high sulphur coal (most of that in the ORBES region) as a non-energy resource. The use of (legal) coal also stresses other areas, such as transportation; western low-sulphur coal must be brought into the ORBES region. This transportation impact can be lessened by developing successful commercial methods to remove sulphur from eastern coal and thus reinstating it as an energy resource again. One such method is wet stack gas scrubbers, the use of which requires large quantities of limestone (lime).

The overall thermal efficiency for fossil plants is about 38% for eastern Kentucky low sulphur coal using no scrubbers. It is near this value for western coal too. Plants with scrubbers have reduced efficiencies of about 36%. Light water reactors (LWR) plants can approach 33% thermal efficiency at best and may be as low as 31% when energy intensive thermal discharge schemes are used.

Fossil plants provide much higher temperature and pressure steam than nuclear plants, resulting not only in the higher thermal efficiency just noted, but the use of more compact turbo-generators. The coal-fired boiler supplies steam to a 3600 rpm, two pole turbo-generator, while the nuclear reactor must be connected to a larger but slower 1800 rpm, four pole turbo-generator. The low speed unit is about half again as large as the

high speed turbine. Given a finite amount of material resources, there is less impact in building coal-fired turbo-generators than a nuclear steam supply system with turbo-generators. There are, of course, other compensating features of nuclear plants that offset their material resources impact.

D.4.1 COAL

The main impact of the growth scenarios will be the reduction in coal reserves. The primary concern will be the reduction of western and ORBES region coal reserves due to the four RTCs being studied. Both types of coal are presently being used in the ORBES region. Low-sulfur western coal will probably continue to be imported in the future.

The terms "reserves" and "resources" are often confused and can be very misleading. Coal resources refers to the total amount of coal expressed in tons or in BTUs. Coal reserves refers to the total recoverable amount in tons or in BTUs. Environmental restrictions and economics define the percentage of resources which are recoverable for a given mining operation. In the State of Illinois, for example, there is an estimated coal resource of approximately 161 billion tons. Using current mining techniques, only 45% is recoverable. This implies that there exists a coal reserve of some 65 billion tons in Illinois alone. Of this reserve, 12 billion tons can be obtained from surface mining operations, and the remaining 53 billion tons can be recovered through underground mining. Without the use of commercial sulphur removal, much of these reserves are no longer a legal energy source.

Western coal deposits and ORBES region deposits are significantly different in many properties. The coal found within the four-state region

has a high sulfur content with the exception of Eastern Kentucky coal. The sulfur content varies with each different deposit, however, for the purpose of this study, an average sulfur content of 3.5% will be assumed for ORBES regional coal. The western coal has a sulfur content of less than 1%. Burning high-sulfur coal, without sulfur removal equipment, adds unacceptable levels of pollutants into the air. There are many restrictions involving the combustion of high-sulfur coal. The cost of meeting these restrictions with ORBES coal justifies importing large amounts of low-sulfur western coal.

There is also a significant difference in the BTU content of western and ORBES regional coal. For this study, the average heat content of western coal is assumed to be 8,500 BTU/lb. and for ORBES regional coal 11,500 BTU/lb. Therefore, a greater quantity of western coal is required to produce the same amount of electric energy.

There are a variety of mining techniques. Western coal is removed through open-pit operations. The coal seams are very thick and an 85-90% extraction efficiency can be achieved. The coal mining in the ORBES region consists of strip and underground mining. Coal deposits greater than 50 cm thick at depths less than 45 meters are considered strippable coal resources. Deposits greater than 70 cm thick at depths more than 45 meters are considered deep or underground mining resources. The amount that can be practically recovered depends largely upon the terrain. The thicker deposits will naturally be exploited first. The average deposit thickness of coal mined in Illinois in 1970 was 1.9 meters. This is somewhat thicker than many other states. The extraction efficiency of a strip mine operation is approximately 80%.

The extraction efficiency of underground mines depends largely on the type of operation. In areas where land subsidence has little impact, such as in hilly, sparsely populated, nonfarming land, as much coal is removed as possible. The mine is expected to collapse after the coal is removed, resulting in land subsidence. The extraction efficiency of this type of operation is 65 to 70%. In areas where land subsidence cannot be tolerated, i.e. populated areas with a large grain-farming industry, pillars of coal are left unmined to insure against land subsidence. Extraction efficiency of 45-50% results from this kind of operation.

The total amount of coal required per generating unit depends on the type of coal used. For comparative purposes, a 36% overall plant efficiency and 47.8 capacity factor was assumed. The following table shows coal required per year for a BOM scenario 1,000 MW(E) unit and a Ford Tech Fix 600 MW(E) unit:

TABLE D.4-1

Coal Required for a BOM 1000 MW(E) Unit and a Ford Tech Fix 600 MW(E) Unit

Size of Unit	Exclusively Western 8,500 BTU/lb. fuel	Exclusively ORBES Region 11,500 BTU fuel
600 MW(E) (FTF)	1.38 million tons	1.03 million tons
1,000 MW(E) (BOM)	2.32 million tons	1.73 million tons

Tons/year of coal required

If regional coal (high sulfur) is chosen for the fuel, then SO_2 removal equipment is required to meet air standards. This requires cumbersome equipment which would reduce the overall plant efficiency from 36% to 34%, requiring about 5% more coal than indicated in the chart.

An acceptable method of coal combustion is to burn a mixture of western and regional coal. The mixture would be such that the amount of high sulfur regional coal is maximized while still remaining within air standards.

The following tables demonstrate the increases of coal production necessary for each of the scenarios. The table is based on the assumption that western coal will supply one-third of the total energy, except that Kentucky will use its own eastern coal, which is low enough in sulfur to meet air standards. A 47.8 capacity factor and 35% efficiency were assumed.

TABLE D.4-2

Electric Utility Consumption of
Coal in Millions of Tons Per Year

	1975		1985	
ORBES Portion of State Only	Imported Western Coal	ORBES Regional Coal	Imported Western Coal	ORBES Regional Coal
Illinois	7.9	11.8	10.8	16.0
Indiana	8.2	12.2	13.1	19.6
Ohio	16.0	23.9	19.7	29.4
Kentucky*		19.2		32.2
ORBES Total	32.1	67.1	43.6	97.2

*Kentucky is not expected to import western coal, since there are low sulfur, high BTU coal deposits being mined in Eastern Kentucky.

TABLE D.4-3

Projected Electric Utility Consumption in 2000
of Coal in Millions of Tons Per Year

ORBES Portion of State Only	BOM 50-50		BOM 80-20		Ford Fix 100% Coal		Ford Fix 100% Nuclear	
	Imported Western	ORBES Regional	Imported Western	ORBES Regional	Imported Western	ORBES Regional	Imported Western	ORBES Regional
Illinois	21.1	31.5	28.3	42.3	10.2	15.2	9.0	13.5
Indiana	24.5	36.6	32.4	48.5	13.7	20.5	11.2	16.7
Ohio	39.9	59.4	53.4	79.7	24.0	35.9	17.1	25.5
Kentucky*		57.1		80.8		33.0		27.8
ORBES Total	85.4	184.6	114.1	251.3	47.9	104.6	37.3	83.5

* Kentucky is not expected to import Western coal since there are low sulphur, high BTU coal deposits being mined in Eastern Kentucky.

As expected, the BOM 80-20 scenario represents the greatest coal consumption impact. Approximately four times as much coal will be consumed in the ORBES region in 2000 as in 1975 for the BOM 80-20 mix. The electric utility industry on a national scale consumed 66% of the total coal used in 1974.

There are abundant coal resources in the ORBES region and in the western region to meet any of the projected demands. However, the coal production industry (mining and processing) must be increased significantly. The coal production in 1975 was 78 million tons from Illinois, 28 million tons from Indiana, and 50 million tons from Western Kentucky.

59,539,019

Second order impacts resulting from this increased coal consumption rate involve transportation, land use, pollution, and ash disposal at plant sites. The transportation system between the western coal mines and the ORBES generating units will have to be greatly expanded.

<u>Lime-Limestone</u>

There will be a significant impact on the lime-limestone industry should SO_2 removal equipment, employing wet lime or limestone scrubbing, be used extensively in the future. Limestone is generally a plentiful material in the ORBES region and is mostly obtained from open-pit mining operations. The quantity of lime, limestone, or other carbonate material required for flue-gas desulfurization for a particular plant would depend on the sulfur content of the coal burned, and, more significantly, on the existing EPA emission standards.

Either crushed raw limestone or processed lime can be used in the wet scrubbing process. The production of lime from limestone is a very energy-intensive industry. Approximately 7.5 M BTU are required to produce one ton of lime. About 2.2 tons of lime are used to remove one ton of sulfur from the flue gas. If limestone is used, about 4.7 tons are needed to remove one ton of sulfur.

The total tonnages of limestone and other carbonate materials required to meet the potential new demand, should SO_2 scrubbers be utilized, are quite large. However, on a national scale, the impact to the overall limestone industry (800-900 million tons per year in 1974) would be relatively small. This new demand would increase the existing production by only 3-4 percent. the ORBES states would represent a large portion of this new market.

If, however, because of economic and operation advantages, lime is chosen as the reactant in the wet scrubbers, the impact on the lime industry would be very significant. To meet this new demand, the national (and ORBES regional) supply of lime will have to be significantly increased. The lime industry is currently operating near capacity, so any new demand would necessitate opening new quarries and the construction of new plants. The location of these new plants would preferably be near the power units.

An important impact of using SO_2 wet scrubbers is the waste-disposal, land-area requirements. The waste (ash and sludge - $CaSO_4$) produced by operating SO_2 scrubbers on a 1000 MW(E) 3-4% sulfur coal would fill 1000 acre areas 25 feet deep. Leaching of acid from the sludge could become a site storage problem.

A possible second-order impact would be a change in the quality and quantity of coal-limestone water in the river basin (Kentucky in particular) that is available for the making of Kentucky whiskey. Whereas this second-order impact is local or at most multi-county, higher order impacts on the quality of this product may be global (5).

Construction Materials

Construction of the new power plants will have a short-time local impact on the availability of material (crushed rock, gravel, cement, lumber, and road material) and large dirt-removing equipment. Site counties could experience shortages of these things during the 3-4 year peak construction period. Nuclear units being designed for greater seismic loads use more material and have a longer construction period than coal units.

An accurate estimate of construction materials is difficult to obtain because they are all site specific and emphasize material needs that may be

in short supply in the area. Table D.4-4 approximates the construction materials used for a two unit PWR plant at Braidwood, IL totalling 2240 MW(E).

TABLE D.4-4

Approximate Quantities of Construction Materials
for PWR Plant at Braidwood, Illinois

Material	Approx. Quantity Used in Plant (Tons)	Material	Approx. Quantity Used in Plant (Tons)
Aluminum	90	Silver	2
Copper	4000	Steel	20,000
Lead	15	Zinc	200
Nickel	200	Other	400

Other includes asbestos (90 tons), chromium (300 tons), with small quantities of beryllium, cadmium, gold, mercury, molybdemium, platinum, tin, and tungston.

Construction of two 950 MW(E) BWRs at Clinton, Illinois indicates a greater need for steel than is noted in the table above. Their literature on construction shows a need of 43,000 tons of Rebar alone and 5214 tons of structural steel.

The Clinton plant site requires a dam and spillway for cooling water that may use some of the added steel. The rest of the difference in steel requirement may be a typical difference between BWR and PWR reactors.

A positive impact at Clinton site should be noted. The arterial roads have been improved to handle the heavier than usual truck traffic during construction.

The concrete required at the Clinton plant is estimated at 461,000 cubic yards. This is equivalent to the concrete needed for a 50-mile section of a four-lane interstate. If all nuclear units took the same amount of concrete and coal units somewhat less, the BOM 50-50 mix requires enough concrete to pave about 4000 miles of interstate. The Ford Tech

Fix RTC would need concrete equivalent to 900 miles of four-lane interstate. Note that the 4000 miles is on the order of existing interstates in the region. One would expect that local shortages of good quality construction material will exist during the construction phase of each plant site.

Crushed rock and gravel are normally obtained locally because it would be uneconomic to haul it a long distance by truck. This drain may deplete several local sources of gravel and crushed rock. This would provide an additional land-use impact locally which could range from insignificant to severe depending on the site and local terrain.

D.4.2 URANIUM

Exploration for uranium requires core drilling of holes in the earth's surface to identify and delineate economic uranium deposits in order to establish known reserves for future recovery. The amount of known reserves discovered is proportional to the amount of feet drilled. Exploration holes drilled for uranium and other resources perforate the surface of our country to the extent that it is hard to find a suitable location underground where the integrity of storage is not penetrated. Filling such holes to ensure integrity is difficult and expensive. Cataloging of exploration drillings is far from complete. Many wildcat drilling records have been lost and holes have been left uncapped. Most of the U S A 's uranium comes from sandstone and mudstone deposits of the Colorado Plateau, the Wyoming Basins, and the Gulf Costal Plains of Texas.

As a resource, uranium has been used mainly for its energy-producing potential. Its use as a heavy metal has been limited; depleted uranium, being stronger than lead, is used as a shielding material against gamma rays.

The potential of uranium as an energy source depends upon its use in nuclear reactors. The anticipated growth of nuclear power will consume presently known reserves by the early 2000's if the uranium is used strictly in light water reactors of either the pressurized water reactor (PWR) or boiling water reactor (BWR) type with a throwaway cycle. Using plutonium in a self-generated mixed oxide form will extend the energy available another half century. If the plutonium is utilized in breeder reactors, such as the liquid metal fast breeder reactor (LMFBR), the energy from the uranium resource can be extended several centuries.

The LMFBR makes use of the plutonium economy of uranium. Another form of uranium fuel, thorium, is also available. Thorium used in high temperature gas-cooled breeder reactors can breed U-233, which can approximately double the potential energy available from uranium.

Both uranium and thorium are widespread over the Ohio River Basin, but they are in concentrations (low ppm) that are presently uneconomical to recover. They are obtained mainly from underground river basins in the Rocky Mountain states in 0.1 to 0.2% quantities in the ore.

As far as uranium ore depletion is concerned, this study assumed that if an ore deposit required underground mining because of depth, only about 50% or less of the ore in the deposit would be recoverable due to the mining method used. If surface mining is used, 80% or more of the ore is assumed to be recoverable.

Uranium mining provides an impact on transportation requirements on a site or local basis. A complete ore hauling system may need to be developed from the ore site to a suitable milling and ore concentration site. Transportation may be by truck, rail or endless belt, depending upon the site.

Considering a 60% capacity factor for nuclear units with no fuel recycle, the yearly mining requirement for each 1000 MW(E) power plant is about 110,000 tons or ore. This ore is transported something less than 50 miles to a milling operation to get about 191 tons of natural uranium out of it. The reamining material is solid tailings at the mill that contains radioactive Ra^{226} and Th^{230} that has been unearthed so that they are now a source of radioactivity. If the uranium came from an open pit mine, as much as 2.5×10^6 tons of overburden may also have been moved.

Identifiable impacts of uranium mining are: reduction in uranium reserves; land use for open pit/or underground mining in the Colorado Plateau, the Wyoming Basins and/or the Gulf Coastal Plain of Texas; building roads from the mines to the mills if they do not exist; uncovering low-level radioactivity by removing overburden; low-level radioactivity from solid tailings at the mill; acid or basic water runoff from the milling operation; and some local airborne particle discharge from the crushing operation at the mill. The shipping of natural uranium as U_3O_8 is negligible in any form of impact. Each reactor requires an initial load of about 430 tons of natural U_3O_8.

Considering the most intensive nuclear commitment, the BOM 50-50 mix, the eighty eight 1000 MW(E) plants would require about 38,000 tons of U_3O_8 for initial loads and have a lifetime U_3O_8 commitment of about 504,000 tons. This amounts to about 1/2 of the USA's probable $30/lb. resources. This may mean several things:

1. The BOM 50-50 is too great a nuclear commitment if only LWR's are considered.

2. Mixed oxide reloads (plutonium recycle) wil be a necessity and possibly as economic, hence easing the U_3O_8 requirement.
3. The breeder reactor must be commercial and as far along as the LWR by 2000 to 2010.
4. The thorium cycle of high-temperature gas-cooled reactors, light water breeder reactors, and gas-cooled reactors may need to be used to extend the energy calendar should fusion be further off than presently thought.

The BOM 80-20 mix has, of course, a lesser impact on uranium ore requirements, but it is greater than either of the Ford Tech Fix RTC's. As a matter of fact, the 100% coal Tech Fix case ends up with only 10% of the region capacity being nuclear. This is a lower percentage than exists presently in the state of Illinois.

D.4.3 FERROUS ORES

A considerable amount of iron and steel are needed for the various RTCs. If only the power plant requirements are considered, more ferrous ore is required for nuclear plants than for coal-fired plants. This would include the coal handling equipment and scrubber at the plant site. The nuclear plant has a larger turbo-generator and a larger concrete structure for the turbo-generator than the coal plant. The primary and secondary reactor containment vessels, and piping and water clean up systems, are more elaborate than the coal boiler and sulfur removal equipment. If the transportation equipment required to support the nuclear and coal fuel systems is included in the comparison, the coal system seems to be more ferrous-ore intensive, mainly due to the coal car requirements and daily use of the transporatation system (especially if by rail).

The reserves of ferrous ores are not in the ORBES region; hence any depletion impact is on the national supply. The material required is significant, but in terms of reserves, is rather small.

Conversion of ferrous ores to special steels provides a generic impact for all nuclear plants, since the material is nuclear stamped (N-stamped) so that each heat of steel can be traced for possible generic faults or characteristics. Critical components in the nuclear steam supply system require N-stamped material; hence a fault, say a crack developing in one reactor piping system, may require the examination and possible interruption of operation of other reactors that have similar generic designs or material heats. This may be a plus feature in terms of safe operation in detecting impending failures; however, it is an interruption of operation where such faults are isolated and not found to be generic. Additional reserve capacity has to be built into the power system to handle such shutdowns.

D.4.4 FINAL IMPACT AND ENGINEERING ECONOMIC ANALYSIS OF THE FOUR SCENARIOS

The cost of electric energy distributed to the consumer is made up of two major parts, an investment charge and a production cost that includes distribution.

Investments and the Four Scenarios

The investment cost for a coal-fired power plant is less than for a comparable nuclear plant, resulting in a correspondingly lower investment charge. To be competitive with coal, the nuclear plant must offset this first cost disadvantage by having a considerably lower fuel cost, and in most cases for base load applications, it does. There must, therefore, be a typical set of economic, legal, environmental, social, etc. conditions that

would lead the ORBES region to have either the BOM 50-50 mix, the BOM 80-20 mix, the Ford Tech Fix 100% coal mix, and the Ford Tech Fix 100% nuclear mix.

To be more specific, neither of the BOM scenarios would come about unless electric energy costs remained comparatively low and the energy growth was likewise stimulated by the nation's economy. The BOM 50-50 mix would materialize most logically with the nuclear units exhibiting a lower energy cost for base load operation. If this attractiveness did not exist, the percentage of nuclear units purchased by electric utilities would not have reached the 50-50 proportion with coal. Similarly, the BOM 80-20 mix would occur only if the relative cost of electric energy was low to stimulate the energy growth and that the nuclear plant first cost was much larger than for coal units. In this manner, only a small percentage of nuclear units could be afforded as base load units. The other impacts along with this one will determine the soundness of either of the BOM scenarios. Whereas only the first cost differential between nuclear and coal plant cost was cited several other items could contribute in shifting the plant mix. It should be noted that the 1975-85 mix now spoken for by electric utilities is near the 50-50 mix ratio. Some items that may affect electric utilities decision making are:

1. Relatively higher uranium ore prices.
2. Higher fabrication cost.
3. A wider differential in first cost of nuclear and coal plants.
4. Continued indecision on mixed oxide fuel for LWR's (plutonium recycle).
5. Quite an increase in spent fuel reprocessing and unfavorable radioactive waste disposal policy.

6. Some reduction in future coal prices, transportation costs and/or sulfur removal equipment.
7. Proven reliability of SO_2 removal technology.
8. Favorable mining conditions for ORBES coal and/or for western coal resulting in an economic advantage.

The Ford Tech Fix mixes can only be justified by high energy cost affecting the growth of our economy along with rigid conservation measures to limit per capita energy use. It may also have been caused by shortages in the materials resources area, failure to meet designated discharge limits by new units now planned. The shift between nuclear and coal is for reasons similar to that for the two BOM scenarios.

<u>Financial Impact of Scenarios</u>

The financial impact of the capital investments required to develop each of the four RTCs can be at best estimated from current data obtained recently from three electric utilities in Illinois (Ref. 4). The study dates were the same as for the RTCs but the mix might approach the BOM 50-50 mix. The financial impact does not include the development of coal mines, limestone quarries, uranium mines or the other industries needed to build power plants at the higher than present rate. The rate of fuel purchase at 1985 and 2000 is estimated on the basis of today's costs and expected energy production.

The table that follows just sums the total dollars required to build up the capacity of the ORBES region to each RTCs capacity. There is no attempt to time value these numbers at this stage of the project.

TABLE D.4-5

Financial Investment Impact

BOM
(Billions of Current Dollars)

Cost Function	1985		2000		
	50/50	80/20	50/50	80/20	% 1985 50/50 only
Power Plant Construction	34.1	34.1	226.6	206	63
Pollution Control	4.4	4.4	20	30	8
Transmission & Substation	7.9	7.9	49.4	49.4	15
Distribution & Substation	6	6	37.5	37.5	11
General Expenses	1.5	1.5	9.4	9.4	3
ORBES Region	53.8	53.8	342.9	332.3	100
Capacity additions MW(E)	29,829		186,602		(Task I)

Tech Fix

Cost Function	1985	2000	
		100% coal	100% Nuclear
Power Plant Construction	34.1	40.2	45.6
Pollution Control	4.4	5.7	2.5
Transmission & Substation	7.9	9.5	9.5
Distribution & Substation	6	7.2	7.2
General Expenses	1.5	1.8	1.8
ORBES Region	53.8	55	66.6
Capacity Additions MW(E)	29,829	35,800	35,600

In developing the financial investments needed for the BOM 80-20, it was assumed that the power plant construction costs (nuclear to coal) differed by \$350/kw (assuming that scrubbers were figured in under pollution control). The pollution control cost figures indicated a price of \$197/kw for that item. When both items were figured together, nuclear and coal plants differed then by \$153/kw on first cost.

At first glance, the accumulated investment by the year 2000 is rather impressive. It must be remembered that the BOM RTCs assumes that the economy, all phases of it, requires the energy production capacity. It should also be noted that the higher cost per kw of capacity that we are now experiencing will by 1985 have increased the electric utility rates to the extent that the lead time of construction prepayments can be better absorbed in the later years than now. Some form of allowance of funds during construction (AFDC) or construction work in progress (CWIP) payment will have to be figured into the rate structure in the near future or electric utilities will not meet growth requirements until they are past due and hardships actually develop. Social and public appreciation of this financial problem has not been met with any seriousness on the part of society.

Whereas the BOM 80-20 shows about \$10 billion less first cost, the energy component of cost will more than compensate for the difference.

To compare the energy cost of the two BOM RTCs at year 2000, the capacity factors of nuclear and coal were both assumed to be the load factor of 47.8% for the region. Further, assume that nuclear fuel cost is 85¢/MBTU and coal is \$2.00/MBTU (including the lime needed for high sulfur coal), resulting in production costs for the region as shown in Table D.4-6.

TABLE D.4-6

Fuel Costs per Year of Two BOM RTCs at Year 2000

Generation	BOM 50-50	BOM 80-20
	Fuel cost/year	Fuel cost/year
Nuclear	$\$3.17 \times 10^9$	$\$1.22 \times 10^9$
Coal	$\$7.76 \times 10^9$	$\$11.61 \times 10^9$
TOTAL	$\$10.93 \times 10^9$	$\$12.83 \times 10^9$

The BOM 80-20 fuel cost for the values assumed is 17% higher than the BOM 50-50 RTC. To overcome the first cost advantage of the BOM 80-20 RTC, it would take less than 8 years out of the 30 to 40 years expected use of the plants.

Investment vs Fuel Cost Trade Off - Nuclear vs Coal Plants

To indicate the relative size of fuel cost differential that is needed to offset a first cost price differential consider the following: an investor-owned electric utility finds it has to pay \$100/kw more in first cost for a nuclear plant than for a coal plant. The extra investment charge expressed in cents/kwh is

$$C_I = \frac{\$100/\text{kw} \times P'_n \times 100}{8760 \times cf}$$

Where P'_n is the depreciable fixed charge rate for the nuclear plant investment and cf is the unit's capacity factor and C_I is the investment cost component of energy in cents/kwh. For our present study, the load factor of 47.8% is also assumed to be the plant capacity factor and P'_n may range from 0.12 to 0.15 depending upon the utilities particular cost of money.

Then an extra \$100/kw of capacity would cost

$$C_I = \frac{100\ (.12 \text{ to } .15)\ (100)}{(8760)\ (.478)} = .29 \text{ to } .36¢ \text{ per kwh}$$

more for a nuclear plant. In order to overcome this extra investment cost, the nuclear fuel cost must be less by that same amount. It also means that the coal fuel cost could be higher by this amount. Converted to thermal energy cost, the nuclear fuel must be less by 28 to 35¢/MBTU. Because of the higher efficiency of coal plants, this converts to a higher coal cost of 32 to 40¢/MBTU to show equivalence.

Recent fuel cost estimates for the Clinton Nuclear power plant in Illinois, scheduled for 1981 operation, indicates a lifetime levelized nuclear fuel cost of about 50¢/MBTU. Comparing this fuel cost to Illinois coal at a similar site and using today's prices is about \$1.25/MBTU without scrubbers. Since scrubbers are needed to make Illinois coal emissions acceptable to air standards, an additional 30¢/MBTU is required for limestone. Comparing 50¢/MBTU to \$1.55/MBTU, more than \$250/kw differential in nuclear and coal plant investment cost can be tolerated before the overall electric energy cost favors the coal plants.

Relevance of Load Factor and Capacity Factor

Electric utilities will load their most cost efficient plants first, hence nuclear units would be loaded first in most cases followed by the best coal units commensurate with reliable load distributions and system reliability. At this point, an attempt was made to see if electric utilities could live with each of the four RTCs from the capacity factor standpoint. It was assumed that the utilities would attempt to have a higher capacity factor on the nuclear units, following load with the coal units (within

[illegible]

limits) and then using peakers for the short daily peak requirements. Capacity factors of 0.6 and 0.65 were assumed for nuclear units and the following table shows corresponding results for coal plants. Whether the utility can tolerate the resulting coal capacity factor remains to be discussed.

TABLE D.4-7

Coal and Nuclear Capacity Factors for Four RTCs

RTC	Nuclear cf_n	Coal cf_c	Nuclear cf_n	Coal cf_c
BOM 50-50	0.6	.41	0.65	.38
BOM 80-20	0.6	.46	0.65	.45
Tech Fix 100%	0.6	.47	0.65	.46
Tech Fix 100% n	0.6	.43	0.65	.41

Since the coal capacity factor cf_c included the peaking units that are vital to electric utility systems, the actual capacity factors for coal plants are higher than indicated. Since peak power usually covers 4 to 5 hours each day, the capacity factor of the coal units do increase a reasonable amount except perhaps for the BOM 50-50 case. The coal capacity factor may be too low. Considering the overall load factor of 47.8%, the nuclear portion of the mix results in too low a capacity factor for the coal plants. All too often the coal plants would have to operate in the unstable flame out region or else nuclar plants cannot be maintained at the capacity factors indicated. Neither case would have been allowed to occur by electric utility management.

In the previous section on tradeoffs, it might have occured to some that the nuclear plant capacity factor should have been a higher value, perhaps the 60% used in this section rather than using the load factor of

47.8%. Actually, neither value gives the true picture. Electric utilities with a fixed rate structure will attempt to base load the power units that exhibit the lowest incremental fuel cost that is consistent with system reliability and transmission losses. In most cases, this would favor the low-fuel-cost nuclear units. There are other criteria to consider. Coal plants are often unstable in operation when the boiler load drops below some minimum value such as 1/3 load. Then, if the load is insufficient, even nuclear units must reduce power and load follow. In reality then, the coal plant being the higher incremental cost unit will have a lower capacity factor than the nuclear unit. To more accurately assess the first cost difference of coal and nuclear, the investment cost difference in ¢/kwh is:

$$C_I = \frac{100}{8760}\left[\frac{C_n P'_{nn}}{cf_n} - \frac{C_c P'_{nc}}{cf_c}\right]$$

where the subscripts n & c refer to nuclear and coal respectively and C_n, C_c refer to total plant first costs in \$/kw. Since $cf_n > cf_c$, the cost difference is lessened between coal and nuclear. P'_{nn} and P'_{nc}, the nuclear and coal fixed charge rates may be different because of the tax breaks given in accelerated tax depreciation and investment tax credit. The tax break usually favors the nuclear unit such that $P'_{nn} < P'_{nc}$, but that situation may change in the case of tax breaks for pollution control devices added to coal plants that may actually reverse the inequality noted.

REFERENCES

1. Corey, Gordon R. A Comparison of the Cost of Nuclear vs. Conventional Electric Generation. Commonwealth Edison Company. A talk presented at MIT, November 17, 1975.

2. Rombaugh, C. T. and B. V. Koen. Total Energy Investment in Nuclear Power Plants. Nuclear Technology, Vol. 26, May, 1975.

3. Colby, Jr., L. J. Fuel Reprocessing in the United States: A Review of Problems and Some Solutions. Nuclear News, January 1976, pp. 8-73.

4. Report of the Electric Utilities Panel to the Illinois Energy Resource Commission. Springfield, Illinois, March 1977.

TABLE A - MATERIAL RESOURCES - Coal - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
COAL EXTRACTION	Reduction in reserves		AC,L,MD,(R-N)	AC,L,MD,(R-N)	1	AC,L,MD, (R-N)	AC,L,I,(R-N)	3	BOM
	Land use--overburden removal from strip mines		AC,M,SV,LO	AC,M,SV,LO	1	AC,M,MD,LO	AC,M,MD,LO	3	BOM
	Land use--subsidence from underground mines		AC,L,I,LO	AC,L,I,LO	1	AC,L,I,LO	AC,L,I,LO	3	BOM
	Increase number of mines		AC,M,MD,MC	AC,M,MD,MC	1	AC,M,I,MC	AC,M,I,MC	3	BOM
WET SCRUBBING SO_2 REMOVAL	Limestone used--Increase limestone production		AC,L,I,(R-N)	AC,L,I,(R-N)	1	AC,L,I,(R-N)	AC,L,I,(R-N)	3	BOM
	Lime(CaO)used--increase lime production industry		AC,L,SV,(R-N)	AC,L,SV,(R-N)	1	AC,L,MD, (R-N)	AC,L,MD,(R-N)	3	BOM
	Land use--ash & sludge disposal (on site)		AC,L,SV,LO	AC,L,SV,LO	1	AC,L,SV,LO	AC,L,MD,LO	3	BOM
PLANT CONSTRUCTION	Create shortage of material & equipment		AC,S,MD,LO	AC,S,MD,LO	2	AC,S,MD,LO	AC,S,MD,LO	3	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - MATERIAL RESOURCES - Coal - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
COAL EXTRACTION	Reduction in reserves	BOM, FEA, Geological surveys	M,-	Degradation of area		BOM, state agencies	
	Land use--overburden removal from strip mines	Landowners, Farmers, Real estate	M-SV,-	Can the area be restored?	Continual or discrete restoration or underground mining	BOM, EPA	
	Land use--subsidence from underground mining	As above	M-SV,-	Impact not immediate-who pays for reclamation?		BOM, EPA	
	Increase number of mines	As above	M-SV,-	Priorities of land usage	Hire King Solomon		
WET SCRUBBING SO_2 REMOVAL	Limestone used--Increase limestone production	Landowners, Real estate, Farmers, Drinking public	M,- SV,-	Possible reduction in water quality for making whiskey		BOM, EPA	WCTU will be happy
	Lime(CaO) used--increase lime production ind.	Current lime users	M,-	Creates shortage of production			
	Land use--ash & sludge disposal (on site)	Landowners, Real estate, Farmers, Drinking public	M,-	Land usage-seepage problems		EPA	
PLANT CONSTRUCTION	Create shortage of material & equipment	Other than utility contractors; Local industry	M-SV,-	Material priority Increase production available after construction is complete			

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

D.4-9

TABLE A - MATERIAL RESOURCES - Uranium - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
NUCLEAR RELATED									
EXTRACTION Exploration	Core drilling	AC,L,I, (LO-N)	AC,L,I,(LO-N)	AC,L,I,(LO-N)	2	AC,L,I,(LO-N)	AC,L,I,(LO-N)	4	BOM
Surface	1-Reduction in uranium reserves	AC,L,I,N	AC,L,I,N	AC,L,SV,N	2	AC,L,I,N	AC,L,I,N	4	BOM
	2-Overburden	AC,L,I,N	AC,L,I,N	AC,L,MD,N	2	AC,L,I,N	AC,L,I,N	4	BOM
Underground	Reduction in uranium reserves	AC,L,I,N	AC,L,I,N	AC,L,SV,N	2	AC,L,I,N	AC,L,I,N	4	BOM
PROCESSING Milling	Solid tailings & radioactive waste discharge	AC,L,I,N	AC,L,I,N	AC,L,I,N	2	AC,L,I,N	AC,L,I,N	4	BOM
Enrichment	1-Specific nuclear material safeguards	AC,S,MD, G	AC,S,MD,G	AC,S,MD,G	2	AC,S,MD,G	AC,S,MD,G	4	BOM
	2-Depleted uranium & radioactive waste	AC,L,I,N	AC,L,I,N	AC,L,I,N	2	AC,L,I,N	AC,L,I,N	4	BOM
	3-Lack of enrichment capacity	VU,M,I, (ST-R)	P,M,MD,(ST-R)	VL,M,MD,(ST-R)	2	VU,M,I,(ST-R)	P,M,MD,(ST-R)	4	BOM
Fabricating	Radioactive waste	AC,L,I, LO	AC,L,I,LO	AC,L,I,LO	2	AC,L,I,LO	AC,L,I,LO	4	BOM
CONVERSION Electric Generation	Spent fuel storage	AC,L,I, LO	AC,L,I,LO	AC,L,I,LO	2	AC,L,I,LO	AC,L,I,LO	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.

DURATION: S-short term; M-medium term; L-long term.

INTENSITY: SV-severe; MD-moderately intense; I-insignificant.

GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - MATERIAL RESOURCES - Uranium - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
NUCLEAR RELATED							
EXTRACTION Exploration	Core drilling	BOM-NRC, ERDA, Landowners underground storage	(M-I),?	Holes left uncapped			Better logging of drilling
Surface	1-Reduc. in res. 2-Overburden	NRC, ERDA BOM-NRC, Landowners, Environmentalists, Farmers	(I-SV),- (I-SV),?	Should the overburden be put back?			
Underground	Reduc. in res.	As above	As above				
PROCESSING Milling							
Enrichment	1-SNM safeguards 2-Dep.U & waste 3-Enr. capacity	IAEA,NRC,ERDA NRC,ERDA,BOM NRC,ERDA,IAEA, Utilities	I,- M,- (I-SV),+ -	Normal safeguards Who builds enrichment plant?			
Fabricating	Radioactive waste	NRC	I, o	Leakage or gas emission			
CONVERSION Electric Generation	Spent fuel storage	NRC, ERDA, Utilities	I,- +	Fear of spent fuel			

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

TABLE A - MATERIAL RESOURCES - Uranium - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
TRANSPORTATION Raw Materials	Possible road building or R.R.	P,M,I,MC	P,M,I,MC	P,M,MD,MC	2	P,M,I,MC	P,M,I,MC	4	BOM
Fuel-New	Diversion of SNM	VU,S,MD, RorN	VU,S,MD,RorN	VU,S,MD,RorN	2	VU,S,MD,RorN	VU,S,MD,RorN	4	BOM
Fuel-Spent	Accident during transit	VU,S,I, RorN	VU,S,I,RorN	VU,S,I,RorN	2	VU,S,I,RorN	VU,S,I,RorN	4	BOM
WASTE DISPOSAL Dilution & on Site Storage	Storage tank leakage	VU,L,I, LO	VU,L,I,LO	VU,L,I,LO	2	VU,L,I,LO	VU,L,I,LO	4	BOM
Permanent Storage	Accident in transit	VU,S,I, RorN	VU,S,I,RorN	VU,S,I,RorN	2	VU,S,I,RorN	VU,S,I,RorN	4	BOM
Reprocessing	Gas, liquid & solid Radioactive waste	VU,L,I, ST	AC,L,I,ST	AC,L,I,ST	2	AC,L,I,ST	AC,L,I,ST	4	BOM
	Plutonium Storage	VU,M,I,R	VL,M,I,R	VL,M,I,R	2	VL,M,I,R	VL,M,I,R	4	BOM
	Use	VU,L,I,R	VL,L,MD,R	VL,L,MD,R	2	VL,L,MD,R	VL,L,MD,R	4	BOM
	Safeguards	VU,L,I,G	VL,L,I,G	VL,L,I,G	2	VL,L,I,G	VL,L,I,G	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - MATERIAL RESOURCES - Uranium - 4

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Re[illegible] Te[illegible] and Societal Accommodations
TRANSPORTATION Raw Materials	Roads or R.R.	St. Highway, County Landowner	(I-M),- o	Right			
Fuel-New	Div. of SNM	NRC,IAEA,DOT	I	Normal safeguards			
Fuel-Spent	Accident during transit	DOT,NRC,Public	I,o	Fear of leakage			
WASTE DISPOSAL Dilution & on Site Storage	Storage tank leakage	NRC, Adjacent landowners	(I-M),-			NRC	
Permanent Storage	Accident in transit	Highway & local authorities	(I-M),-	Transportation routes		NRC,DOT	
Reprocessing	Gas,liquid & solid Radioactive waste	Land neighbors Downwind land-owners	(I-M),-	Seepage of liquid, fear of radioactivity		EPA	
	Plutonium Storage	NRC,IAEA, anti-pollution grps., utilities	(I-M),-	Fear of toxic material, loss of energy resource		NRC, IAEA	
	Use	Utilities,anti-pollution grps.	(M-SV),+	Moral issues	Burn pu & reduce resource of this material	NRC, ERDA	
	Safeguards	IAEA,NRC	(I-M),-	Material can be used as threat		IAEA, NRC	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

D.5 TRANSPORTATION IMPACTS

There are four primary methods of coal transportation: conveyor, trucks, barges and rail. For trips of less than 20 miles, any of the four modes could be economical. It is unlikely that conveyors will be used for trips of more than 20 miles, and trucks are rarely used for trips of 50 miles or more. Occasionally, if no rail is available or only a small amount of coal must be shipped, trucks may be used for distances up to 200 miles. Primarily, then, the longer distance shipping (over 50 miles) is by barge or rail, depending upon the particular location of the origins and destinations. Nationally, for 1985, projected coal transportation shares for rail ranged from 63.7 percent to 72.3 percent, and for river, from 8.8 percent to 16.4 percent. It is expected that truck and conveyor transportation of coal will continue at about their current levels of 12 and 7 percent, respectively. The transportation of limestone will increase dramatically if scrubbers are used extensively after 1985. It will be important to examine the locations and extent of limestone within the ORBES region in order to determine which modes of transport will be used and what the resulting impacts will be.

Barge Practice

In 1972 over three-quarters of the total national barge shipments of coal originated on the Ohio River System, including the Ohio, Green, Allegheny, Kanawha and Monogahela Rivers; and most of the shipping destinations were within the Ohio River System as well. By 1985, the Ohio River System will be carrying a reduced share of the increasing total (all modes) coal shipments because of capacity limitations. As these capacity limits are reached, increasing environmental damage due to spills

and leakage of coal dust and increasing accident rates due to crowding can be expected. Current practice in barge transport is to tie multiple barges and a towboat together. On most rivers, the average tow is formed by using four to six standard barges (900 tons, 175 feet by 26 feet). The average length of haul for coal by barge was 341 miles in 1972. From 1969 to 1973, there has been a slow growth in the average number of barges per tow (from 5.4 to 6.5), but there does not appear to be much chance for extensive improvement in the efficiency of barge movements in the next twenty five years. This conclusion can be further justified by the observation that there is currently not much difference between the efficiency (in terms of dollar cost/ton versus distance) associated with the barge industry's average cost as opposed to the industry's best practice cost. If there were a greater difference between the average practice and the best practice, then more potential would exist for improvements in industry efficiency.

<u>Rail Practice</u>

The use of unit trains is increasing, and is seven times as efficient for the transportation of coal as the use of individual hopper trains. Although the use of unit trains requires dedicated equipment and rapid loading/unloading facilities of the type that can economically only be associated with medium to large coal mining operations, a greatly increased use of unit cars is expected in the future. There is currently a wide gap in efficiency in the rail industry's average and best practice, which indicates that there is significant potential for fairly large scale efficiency improvement in the relatively near future, certainly before the year 2000.

Other Modes

Nationally, over 11.5% of total coal shipments in 1973 were by truck. Another method of shipping coal is the use of short-haul conveyors used often in mine-mouth plants and also used to convey coal from the mine to nearby rivers or rail operations. Coal slurry pipelines may also be used, although difficulties in obtaining land passage rights and water rights may delay the use of such pipelines, even in situations where they would be the first choice on economic grounds.

BOM Versus Ford Tech Fix

Under the BOM scenarios there will be a greatly increased demand for coal and limestone transport, particularly in the rail and barge modes. Under the Ford Tech Fix scenarios, only a modest increase in transportation requirements will occur. But the same policy issues that will be described next can be used to improve the system efficiency and/or reduce the relative cost of transportation. A major issue is how to increase the capacities of the transportation system.

There are a variety of policy options: investing in basic research in order to improve technology; developing tax incentives in order to promote the use of unit trains; improving utilization of existing equipment; increasing capacities by developing wider channels and more efficient locks and by updating and/or extending the current railroad track system; and changing the rate structure.

Although there is an assumption that after 1985 extensive use will be made of scrubbers, the transportation needs associated with the resulting sludge and fly ash are assumed to be minimal. Current practice is for these products to be deposited on site.

Because the bulk of uranium ore is first processed and reduced near the mine mouth, the impact of increased numbers of nuclear reactors, even under the 50-50 BOM scenario, will not severely impact the transporation system. The primary modes of transport for radioactive materials are truck and rail. It is projected that by 1980 there will be twice as much nuclear material transported by rail as by truck; and that by the year 2000 there will be four times as much nuclear material transported by rail as by truck. The major issue in the transportation of nuclear material is security with respect to both accidents and sabotage. The BOM scenarios will have relatively greater security problems because of the larger amount of nuclear material which must be transported.

REFERENCES

1. Bureau of Mines, Coal Transportation Practices and Equipment Requirements to 1985, Bureau of Mines Information Circular IC 8796, United States Department of the Interior. 1976.

2. Bureau of Mines, Comparative Transportation Costs of Supplying Low Sulfur Fuels to Midwestern and Eastern Domestic Energy Markets, Bureau of Mines Information Circular, IC 8614, United States Department of the Interior. 1973.

3. Bureau of Mines, Unit Train Transportation of Coal, Bureau of Mines Information Circular IC 8444, United States Department of the Interior. 1970.

4. Blomeke, J. O., C. W. Kee and R. Salmon. "Shipments in the Nuclear Fuel Cycle Projected to the Year 2000," Nuclear News. June 1975. pp. 62-65.

TABLE A - TRANSPORTATION EFFECTS - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
TRANSPORTATION									
Coal									
Raw or processed	Increased demand for unit trains, freight trains and barges	AC,(S,M,L),SV,N	AC,(S,M,L),SV,N	AC,(S,M,L),SV,N	1	AC(S,M,L),SV,N	AC,(S,M,L),SV,N	3	BOM
Ash	Increased demand for freight trains, trucks and barges	VU,(S,M,L),MD,N	VU,(S,M,L),MD,N	VU,(S,M,L),MD,N	1	VU,(S,M,L),MD,N	VU,(S,M,L),MD,N	3	BOM
Nuclear									
Milled uranium to a conversion facility; Converted uranium to an enrichment facility; Enriched uranium to a fabrication facility; Fuel to reactors; Waste to permanent storage	Increased demand for freight trains and trucks designed with appropriate safeguards against the spread of radioactivity	AC,(S,M,L),MD,N	AC,(S,M,L),MD,N	AC,(S,M,L),MD,N	2	AC,(S,M,L),MD,N	AC,(S,M,L),MD,N	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

TABLE B - TRANSPORTATION EFFECTS - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
TRANSPORTATION Coal Raw or processed	Increased demand for transportation	Transportation industries	SV,+	Capacity restrictions	Invest in basic research	DOT	Improved technology
					Tax incentives for improving equipment	U.S.Congress	Improved equipment and industry practice
					Improve utilization	Transportation industry	Better industry practice
					Increase capacity	Corps of Engineers; DOT	Increased capacity in barge & rail sys.
Ash & scrubber sludge	Almost none, due to on site disposal						
Nuclear Milled uranium ore; Converted ore; Enriched ore; Fuel to reactors; Waste to permanent storage	Increased demand	Transportation industries	M,+	Security		Nuclear Regulatory Comm.	Improved security
				Multiple transportation stages	Combine processing facilities	Nuclear Regulatory Comm.	Improved security

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

D.6 WATER USE IMPACTS

Preliminary data from a Task 4 special study indicate that the total consumptive use of water under the BOM 50-50 scenario will be approximately 11% of the 7-day, 10-year low flow through the basin. Although this figure does not seem excessive on first inspection, two other factors should be considered. First, the Mississippi contains inadequate water for navigation at the 7-day, 10-year low flow. Since the water being withdrawn in the Ohio River Basin would otherwise flow into the Mississippi, consumptive use clearly affects the frequency with which traffic on the Mississippi will be interrupted.

A second factor is the comparison of consumptive use to the amount of water originating within the Ohio River Basin (that is, approximately, the difference between inflow and outflow). Here, preliminary figures show that consumptive use will be more than 100% of the 7-day, 10-year low flow excluding "imported" water. One should not, of course, jump to the conclusion that there is inadequate water simply because if all of the upstream users withdraw all of their available water, there will be insufficient water left; but it is important to recognize the extent to which the abundant supply of water in the Ohio River Basin is dependent on importation. As competing uses are developed in other regions, there will clearly be some impact on the Ohio River Basin and downstream areas.

D.6-1

TABLE A - MATERIAL RESOURCE - 1

Water Use Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION									
Underground Coal Related	Water use Acid in drainage water	AC,L,I, Lo-R	AC,L,I,Lo-R	AC,L,I,Lo-R	(1)	AC,L,I,Lo-R	AC,L,I,Lo-R	(3)	BOM
PROCESSING Coal Cleaning	Water use Black solids waste	AC,L,MD Lo	AC,L,MD,Lo-R	AC,L,MD,Lo-R	(1)	AC,L,MD,Lo-R	AC,L,MD,Lo-R	(3)	BOM
CONVERSION Electrical Generation	Cooling tower evaporation	AC,L,MD Lo-R	AC,L,SV,Lo-R	AC,L,SV,Lo-R	(2)	AC,L,MD,Lo-R		(4)	BOM
Coal & Nuclear Related	Blow Down-dissolved solids. Drift	AC,L,MD Lo-R ---	AC,L,SV,Lo-R ---	---	--	---	---	--	---
WASTE DISPOSAL Reprocessing Nuclear	Water use	VU,L,I, R-N	VL,L,I,R-N	VL,L,I,R-N	(2)	VL,L,I,R-N	VL,L,I,R-N	(4)	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - NATERIAL RESOURCE - 2

Water Use

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
			(See legend below)				
EXTRACTION							
Underground Coal Related	Water use Acid in drainage water	Farmers, Real estate Industry	I	---		BOM, EPA	
PROCESSING Coal Cleaning	Water use Black solid waste	As above	I to M	---		BOM, EPA	
CONVERSION							
Electrical Generation	Cooling tower evaporation	Farmers Industry	I to SV	---			
Coal & Nuclear Related	Blowdown-dissolved solids. Drift	People, Real estate					
WASTE DISPOSAL							
Reprocessing Nuclear	Water use Solids in water Some radioactive liquid	Environmentalists Real estate Neighbors	I	---		EPA, NRC	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - MATERIAL RESOURCE - 3

Water Use Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
COMBINED WATER USE									
Entire Electric Power Generation System	Agriculture Water may be withdrawn from usage and use of remaining water may be degraded	VU,M,I, Lo-R	P,M,I-MD,Lo-R	P,M,I-MD,Lo-R	(2)	VU,L,I-MD, Lo-R	VU,L,I-MD,Lo-R	(4)	BOM
Coal & Nuclear Related	Water withdrawn from industrial usage	VU,M,I, Lo-R	P,M,I-MD,Lo-R	P,M,I-MD,Lo-R	(2)	VU,M,I,Lo-R	VU,M,I,Lo-R	(4)	BOM
	Drinking water supplies diminished	VU,M,I, Lo-R	P,M,I-MD,Lo-R	P,M,I-MD,Lo-R	(2)	VU,M,I,Lo-R	VU,M,I,Lo-R	(4)	BOM
TRANSPORTATION	Low level in nav gable waters	VU,S,MD R	VL,S,MD,R	VL,S,MD,R	(2)	VU,S,MD,R	VU,S,MD,R	(4)	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - MATERIAL RESOURCE - 4

Water Use

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
			(See legend below)				
COMBINED WATER USE Entire Electric Power Generation System	Agriculture Water may be withdrawn from usage and use of remaining water may be degraded	Grain & livestock farmers Real estate	---	Priority of water usage	Establish land use priorities	EPA, BOM, DOA Corps of Engineers	
Coal & Nuclear Related	Water withdrawn from industrial use	Industry Real estate	---	As above	As above	As above	
	Drinking water supplies diminished	People Communities, Real estate Industry Cities	---	As above	?		
TRANSPORTATION	Low level in navigable waters	All river traffic	---	As above	?	BOM, EPA Corps of Engineers	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

D.7 IMPACTS: AIR QUALITY AND CLIMATOLOGICAL

D.7.1 ENVIRONMENTAL IMPACTS (AIR QUALITY)

For the purpose of this report, this section will discuss only the primary impacts upon the air quality within the ORBES region. One exception, however, will be the discussion of the subsequent deposition of particulate matter upon the land. Since the atmosphere offers a dynamic medium for the transport of gaseous and particulate pollutants, it can be expected that the environmental air quality has a significant impact upon the other areas of concern covered in this report.

The impact tables for air quality consider four main functions:

1. Mining
2. Processing
3. Transportation
4. Conversion

The impacts for the first three functions (mining, processing, and transportation) are very similar and probably less significant than those of the fourth function, conversion. This dichotomy arises primarily from the way the pollutants are emitted to the atmosphere. This is delineated in the table below:

	Functions	
Characteristics	Extraction Processing Transportation	Conversion
1. Source-Type	Area (not easily containable)	Stack (containable)
2. Emission Level	Ground-Level	Elevated Height
3. Emission Intensity	Low-Moderate	Can be Intense
4. Type of Emissions	Particulate	Gaseous/Particulate
5. Area Effected	Local	Local-Regional

The extraction function of both nuclear and coal will give rise to particulate emissions which may contain trace contaminants. Particulates emitted from nuclear mining operations are of probable higher radioactivity. In the case of surface mining, these emissions arise from the open pits and earthen piles generated in the mining process. For the underground extraction process, the emissions could emanate from the tailings pile.

To make an accurate estimate of the amount of particulates emitted would be difficult. It would depend on the wetness of the earth, the area of the mine, and the velocity of the wind. Also the level of current excavation activities would be of consequence, although such emissions could continue after mining activities have ceased at the site, depending upon the reclamation effort made at the abandoned site.

Since the particles are picked up at ground level and are, themselves, probably quite heavy, one would not expect them to remain airborne for very long before they would be redeposited. Thus, the major impact would be within the locality of the mine. To make an estimate of the average atmospheric concentration of particulate matter, a Gaussian plume model modified for a ground level air source could be utilized. The following computer codes are available or under development:

1. Climatological Dispersion Model (CDM) [3]
2. Air Quality Display Model (AQDM) [1]
3. Multiple Windfield Air Quality Display Model [6,19]
4. Continuous Source Reflection Model (CSR) [7]
5. Air Transport Model (ATM) [5,15]

All of these models to some degree have also been adapted to predict the average deposition of particulate matter at a given location.

If one accepts the assumption of local effects only, then the major distinction between the scenarios will be the number of sites affected. Hence, BOM 80-20 will affect the largest number of sites and, in descending order, BOM 50-50, FTF (100% coal). FTF (100% nuclear) will affect the least number of sites. The actual number of sites affected within the Ohio River Basin would depend upon the mix of the high-sulfur and western coal to be used at the coal-fired plants.

For nuclear-related sites, the list would be as follows:

1. BOM 50-50
2. BOM 80-20
3. Ford Tech Fix (100% nuclear)
4. Ford Tech Fix (100% coal)

This report will assume that most, if not all, nuclear mining activities will remain outside the Ohio River Basin. Note in every case, the BOM scenarios have greater impact than the Ford Tech Fix scenarios due to the predominant increase in the number of power plants imposed by the BOM scenario.

Another source of coal-related particulates is derived from the crushing and sizing of coal. Here there may exist a possibility of partial containment. Since the impacts are similar to those for the extractions of coal, a detailed discussion will not be made. In decreasing order of impact on air quality, the scenarios are:

1. BOM 80-20
2. BOM 50-50
3. Ford Tech Fix (100% coal)
4. Ford Tech Fix (100% nuclear)

Similar impacts arise in the nuclear-ore crushing and concentration processes. Due to the higher radioactivity of the resulting particulate, it is expected that there would be a substantial effort to control its airborne emission. During the isotope enrichment process, especially for uranium, radioactive gases such as uranium fluoride are produced. Due to precautionary measures employed in this process, one could assume that the probability of such gases escaping is very unlikely. In any event, most of the uranium ore processing and isotope enriching will probably occur outside the Ohio River Basin.

Coal dust can also result from the transport of coal in open trucks and railroad cars. Here again the impacts are similar to the above cases. One exception, however, is that the transport of coal may involve urban areas as opposed to predominantly rural areas. This may be one of the most difficult impacts to estimate. The total impact will depend upon the amount of coal utilized in the Ohio River Basin and the points of origin for the coal.

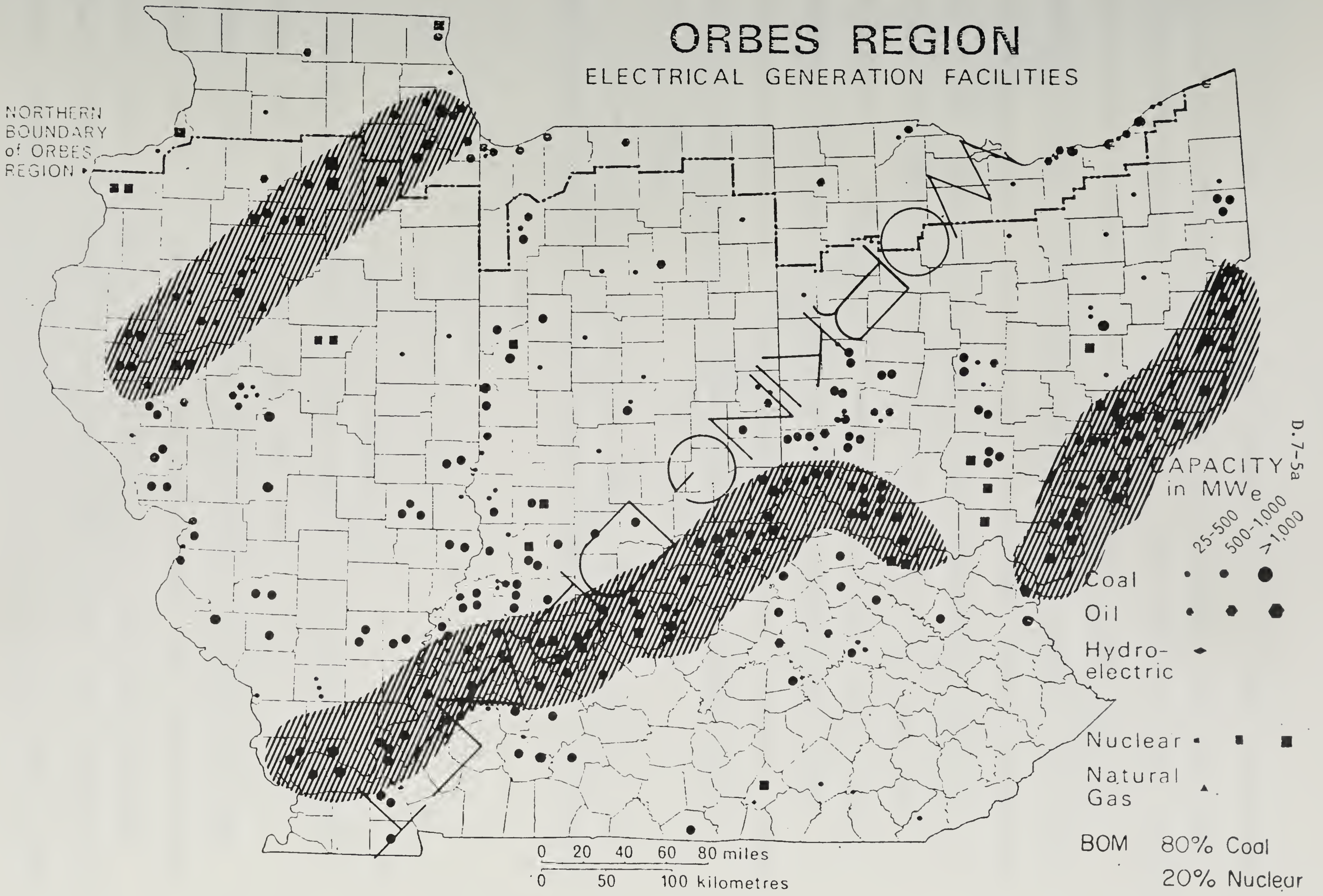
The major impact upon air quality in the Ohio River Basin results from the electrical conversion of coal. The emissions of concern here are gases such as SO_2 & NO_x, oxidants (O_3), and particulates (fly ash) laden with trace contaminants such as cadmium, lead, zinc, arsenic, etc. Due to the enormous amounts of coal consumed by a 1000 MW(E) coal plant (approximately 3 million tons per year), the potential problem is significant. The actual amount of emissions depends upon the mix of low- and high-sulfur coals utilized, the pollution abatement procedures being employed, and the percentage of capacity at which the plant is being operated. The EPA has published information to enable one to estimate these emissions [4,17].

Once the emissions have been released, they react within the plume and can change chemical form. One reaction of particular concern to the environmentalist is the oxidation of SO_2 to SO_3 and the subsequent association with water to form H_2SO_4 or sulfuric acid.

The direct impact of these emissions result in substantially elevated atmospheric concentration of pollutants within 10 to 20 km downwind of the plant. The actual concentration of pollutants at a given point depends upon (among many other factors) the direction and speed of the wind, the mixing condition (stability) of the atmosphere, and the height of the smokestack. The Gaussian plume models, mentioned earlier, supply a vehicle for predicting the average concentrations of pollutants at ground level in the vicinity of a given plant, provided the applicable meteorological data for the region can be ascertained. Most of the above models are also able to predict the average deposition rate of fly ash upon the earth.

The latter gives rise to a subsequent problem called refloatation. If the particulate emission is deposited on a hard surface such as the sidewalk or streets then a later wind or passing traffic can lead to deposited particle becoming airborne again. In the urban areas, this can pose a significant impact. Perhaps the best abatement procedure is the regular sweeping of the streets and parking lots.

A major concern is the placement of the majority of the coal-fired plants along the Ohio River corridor. This results in the deployment of plants along a straight line whose direction corresponds to a more prevalent wind direction for the corridor (see Fig.D.7-1). Thus, it is expected that given a certain set of meteorological conditions a cascading effect could evolve; that is, the already elevated concentration in one location due to



D.7-5a

FIGURE D.7-1

Year 2000

a coal-fired power plant in the near vicinity could be further elevated by the emissions from another power plant further downwind. This may result in what environmentalists call an episode in which many of the EPA standards are violated. To study this phenomena, very sophisticated analytical modeling is needed. (It is hoped that a preliminary analysis can be made for the final report.) Also one needs to study what effects the Ohio River and its major tributaries have upon the local meteorology [12,13,14]. It is known that a large body of water can significantly alter the local meteorological conditions toward conditions which would further elevate atmospheric pollutant concentrations. This is expected to be a major concern because many of the plants in this corridor will probably be placed near the river to facilitate the use of barges and to provide access to water for cooling.

In terms of overall environmental impacts to the air quality of the ORBES region, the scenarios from gravest to least serious are the following:

1. BOM 80-20
2. BOM 50-50
3. Ford Tech Fix (100% coal)
4. Ford Tech Fix (100% nuclear)

Another source of emission arises from the coal gasification industry. Several pilot plants have been built and, indeed, this may be a viable industry by 1985. In the Bureau of Mines scenario, two plants have been located in each of the four Ohio River Basin states. Since the technology is still under development (though feasibility has been shown), definite emissions cannot yet be set. It can be assumed, however, that emissions and effects will be very similar to those of the coal-fired power plant in many

respects, but exceptions exist. For example, hydrogen sulfide may be a more prevalent emission since hydrogen is a primary input to generation of synthetic gas. Many of the pollution abatement processes used in coal-fired power generation could also be applied to coal gasification, but one would expect some modifications would need to be made.

Another intensely significant impact could arise from a major nuclear power plant accident with core melt down and rupture of the pressure vessel and containment structure with a subsequent release of radioactive material to the environment. It is believed that the probability of such occurrence is very unlikely but this is point of considerable debate. If the situation did occur, it could lead to significant impacts upon the surrounding vicinity although the radius of influence is subject to question. The Gaussian plume models can again be used to model the dispersion of the radioactivity. Several governmental agencies have made extensive studies to access the resulting impacts. The interested reader is referred to these studies.

Having cited the major air quality first-order impacts upon the region, it is expected that several second-order impacts would arise due to the dynamics of the pollutant-laden atmospheric medium. It is through these second-order effects that the public is usually made aware of the pollution problem. Once the public realizes a level of air pollution, the EPA is usually invoked to measure and regulate the concentration level of pollutants in the atmosphere. EPA has several options among which may be:

1. Force the management of a power station to meet legislated emission standards.

2. Impose new emission standards upon the source.

3. Ask for a court injunction against the source's operation, particularly under certain meteorological conditions.

Among the second-order effects to be noted perhaps the most obvious is the change in the appearance of the atmosphere and climate (weather). An extensive discussion of these effects is made in the second part of this section. Further, the deposition of particulate matter laden with trace contaminants and the gaseous pollutants could have impacts upon the biological species, including man, in the region. (See Biological and Public Health Impacts.) Attention will now be focused upon the second-order climatological impacts.

D.7.2 CLIMATOLOGICAL INPUTS

Climatological impacts can be subdivided into several categories, depending upon the geographical size or proximity of the impact. For convenience in the following discussion, three different scales will be employed.

The first is local, which can be defined to range from an impact that is quite local, such as fogging and visibility impairment on a highway adjacent to a cooling pond or cooling tower, up to and including multi-county impacts, such as increased snowfall downwind from a pollutant source as a result of increased particulate matter in the atmosphere. Another example of a local impact might be the deterioration of visibility within five, ten, or twenty kilometers (~3-12 miles) of a pollutant source, causing subsequent loss of Visual Flight Rules (VFR) conditions necessitating more restrictive and costly Instrument Flight Rules (IFR) operations at an airport facility within that locality.

A regional spectrum of climatological impacts is also possible, ranging in geographical scale from portions of a state up to several states, and ultimately to a regional impact. An example of the latter would be increased acid rainfall on the western slopes of the northeastern Appalachian Mountains due to airborne pollutant discharge throughout the lower Ohio River Basin.

The third and final category of climatological impacts to be considered are those which are global in nature, such as the introduction of certain substances to the atmosphere whose long-term residence times allow them to become mixed into the global atmospheric system. These substances include carbon dioxide released during combustion of fossil

fuels, fine particles that become windborne due to strip mining operations and subsequent wind erosion, ozone, various chemicals and pollutants.

The long-term residence times of many of these pollutants dictate that global climatological impacts will tend to have slight immediate effects, but long cumulative impacts, ranging from weeks in some cases up to millenia or more in others.

These distinctions between local, regional, and global scale are somewhat arbitrary; however, the coarseness of this scale is considered to be adequate at this point for the needs of the study. Local climatological impacts are often short term in duration and usually easily identifiable as the result of the operation of an existing facility. Furthermore, once the cause is removed or adequately remedied, such as the completion of a mining operation, the climatological impact will often be eliminated. Local climatological impacts that are severe in intensity usually impact only the residents of the local area. The population of the basin as a whole would normally have little concern or interest. An exception would be, for example, a local climatological impact which would cause a response from an environmental group defending the last known habitat of an endangered species. Local impacts such as visual obstruction of highways due to fog from cooling towers, while being locally severe, do not normally affect the lives and livelihood of the vast majority of basin residents.

Micro and Regional Climatological Considerations

Table D.7-2 presents those climatological impacts which are considered, at first cut, to be significant. The significant impacts on a local scale appear to be restricted to local fogging effects in the vicinity of cooling

towers, increased snowfall and rainfall in the multi-county region downwind, and a general increase in atmospheric humidity. The majority of the above impacts are obvious to all interested parties, and action will be requested from appropriate agencies, typically the U.S. Environmental Protection Agency. The parties at interest can be expected to react in a strong manner, and the agencies will see that existing environmental standards are enforced.

The regional climatological impacts anticipated are few in number, but quite significant. Increased precipitation, lowering of general visibility, and other impacts will all occur to some extent. An additional significant climatological effect will be increased acid rainfall on the western slopes of the northeastern Appalachian Mountains, as discussed in [9]. The contrast between the 80-20 and 50-50 RTCs will be apparent due to the increased sulfur release into the atmosphere associated with the 80-20 RTC and its higher discharge of combustion products and byproducts. The parties at interest will include residents outside of the basin, although it may be difficult for them to prove a cause-and-effect relationship. The agencies involved will be, typically, the U.S. Environmental Protection Agency and the affected state EPAs.

Global Climatological Considerations

Global effects on climate and world weather patterns are hotly debated in the current scientific literature, with particular emphasis on long-range world temperature trends.

There are essentially four schools of thought concerning long-term world temperature trends and the cause of ice ages. The first group believes that increased release of carbon dioxide from industrialization

and burning of fossil fuels will cause appreciable warming of the earth (the so-called "greenhouse effect"), with subsequent melting of the polar caps and consequent disaster. An overview of the basic argument is given in [16].

The second school of thought includes the dust believers, who suggest that the particulates released into the atmosphere as a consequence of increased industrialization will cause a reduction in incoming solar energy and a subsequent chilling of the earth's temperature [2,5].

A third school of thought is comprised of those who believe that exogenous variables such as changes in the earth's orbit are the principal cause of ice ages and periodic climatic change [8].

A fourth and a relatively unknown viewpoint concerning long-term temperature fluctuations is the closed loop cybernetic systems theory approach, which suggests that the periodic fluctuations in the world's climate are the result of the world acting as a set of closed loop, non-linear differential equations for which a periodic limit cycle is a stable (but not the only) system response [10,18]. This fourth school is a hybrid version of the first and third schools that is capable of explaining most known climatological phenomena, including periodic glaciation and even earlier climate behavior.

The major belief common to all four schools of thought is that the earth's temperature regulation mechanism is largely unstable. Proponents of continued energy use and development, especially of fossil fuels, must realize that even small or modest perturbations in the radiation heat balance coefficients that dictate the earth's temperature may result in large, dramatic, and possibly irreversible changes in the earth's temperature

behavior. Many positive feedback loops exist that reinforce the perturbation and thus cause the system to depart substantially from its current value.

In this study, the Ohio River Basin can be considered as a microcosm of industrialized society. Thus, attention must be given in the study to the impact of continued industrialization and its effect on world climate.

REFERENCES

1. Air Quality Display Model. TRW Systems Group, U.S. Environmental Protection Agency, NAPCA, Washington, DC (1970).

2. Bryson, R. A. and W. M. Wendland. Climatic Effects of Atmospheric Pollution. Paper presented to the AAAS 1968 National Meeting, Chicago (1968).

3. Busse, A. and J. Zimmerman. User's Guide for the Climatological Dispersion Model. National Environmental Research Center, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, EPA-R4-73-024 (1973).

4. Compilation of Air Pollutant Emission Factors. Office of Air Programs, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, OAP-AP-42 (1973).

5. Culkowski, W. and M. Patterson. A Comprehensive Atmospheric Transport and Diffusion Model. Oak Ridge National Laboratory, ORNL-NSF-EATC-17 (1976).

6. Davis, W. J. AQPM with Multiple Windfields. Report to Purdue Trace Metals Project, NSF (RANN) Grant GI-35106 (1974).

7. Davis, W. J. and D. Metz. A New Model of Particulate Effluent Dispersion with Ground-Level Deposition and Reflection. To appear (1976).

8. Hays, J. D., J. Imbrie and N. J. Shackleton. Variations in the Earth's Orbit: Pacemaker of the Ice Ages. Science, Vol. 194, No. 4270, pp. 1121-1132, December 1976.

9. Johnston, N. M., R. C. Reynolds and G. E. Likens. Atmospheric Sulfur: Its Effect on the Chemical Weathering of New England. Science, 177: 514-516 (1972).

10. Klein, R. E., V. P. Crome, W. R. Heitschmidt and C. M. Zinn. The Greenhouse Effect, Ice Ages, and Atmospheric Carbon Dioxide Revisited via Simulation and Nonlinear Feedback System Theory. Proceedings of the Summer Simulation Conference, San Diego, June 1972, pp. 904-909.

11. Lubkin, G. B. (ed.). Atmospheric Dust Increase Could Lower Earth's Temperature. Physics Today, Vol. 24, No. 10, October 1971.

12. Lyons, Walter A. The Climatology and Prediction of the Chicago Lake Breeze. Journal of Applied Meteorology, Vol. 11, December 1972, pp. 1259-1270.

13. Lyons, Walter A. and Henry S. Cole. Fumigation and Plume Trapping on the Shore of Lake Michigan During Stable Onshore Flow. Journal of Applied Meteorology, Vol. 12, April 1973, pp. 494-510.

14. Lyons, Walter A. and Lars E. Olsson. Detailed Mesometeorological Studies of Air Pollution Dispersion in the Chicago Lake Breeze, Monthly Weather Review, Vol. 101, No. 5, May 1973, pp. 387-403.

15. Mills M. and M. Reeves. A Multi-Source Atmospheric Transport Model for Deposition of Trace Contaminants. Oak Ridge National Laboratory, Report ORNL-NSF-EATC-2 (1973).

16. Plass, G. N. The Carbon Dioxide Theory of Climatic Change. Tellus VIII, No. 2, pp. 140-153 (1956).

17. Guide for Compiling a Comprehensive Emission Inventory. National Environmental Research Center, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, APTD-1135 (1973).

18. Sergin, V. Y. Large-Scale Climatic Variations and Earth Glaciation: A Systematic Analysis. Paper prepared for the 1974 GARP International Study Conference on the Physical Basis of Climate and Climate Modeling, August 1974.

19. Thomas T. and W. Davis. Modeling Particulates in the Gary, Indiana Area. NSF Trace Metals Conference, Oak Ridge, Tennessee. CONF-730802 (1973).

TABLE A - AIR QUALITY - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION * Surface & Underground	Wind blown particules containing trace contaminants	AC,M,MD, LO	AC,M,MD,LO	AC,M,MD,LO	1	AC,M,MD,LO	AC,M,MD,LO	3	BOM
	Wind blown particulates containing radioactive contaminants	VU,M,MD LO	VU,M,MD,LO	VU,M,MD,LO	2	VU,M,MD,LO	VU,M,MD,LO	4	BOM
PROCESSING (Crushing & Sizing)	Wind blown particulates containing trace contaminants	AC,S,MD, LO	AC,S,MD,LO	AC,S,MD,LO	1	AC,S,M,MD, LO	AC,S,MD,LO	3	BOM
	Wind blown particulates containing radioactive contaminants	VU,S,MD, LO	VU,S,MD,LO	VU,S,MD,LO	2	VU,S,MD,LO	VU,S,MD,LO	4	BOM
TRANSPORTATION (Coal only)	Wind blown particulate containing trace contaminants	AC,S,I, (LO-R)	AC,S,MD, (LO-R)	AC,S,MD, (LO-R)	1	AC,S,MD, (LO-R)	AC,S,I, (LO-R)	3	BOM

* The major distinction in the scenarios involves the number of localities affected.

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - AIR QUALITY - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION Surface & Underground	Windblown particulate containing trace contaminants	Residents & farmers near mine.	MD, -	Effect upon local biosystems	Damage suit, injunction against operation	Federal: EPA State: EPA Local: Farm organizations	Very little possibility for control of emission.
	Wind blown particulate containing radioactive contaminants	Residents & farmers near mine	MD, -	Effect upon local biosystems	Damage suit, injunction against operation	Federal:EPA, NRC State: EPA Local: Farm organizations	Very little possibility for control of emission
PROCESSING (Crushing & Sizing)	Wind blown particulate containing trace contaminants	Residents & farmers near processing facility	MD, -	Effect upon local biosystems	Damage suit, set standards, injunction against operation	Federal: EPA State: EPA Local: Farm organizations	Building containment facilities about equipment may partially reduce emissions, some can not be controled
	Wind blown particulate containing radioactive contaminants	Residents & farmers near processing facility	MD, -	Effect upon local biosystems	Damage suit, set standards, injunction against operation	Federal:EPA, NRC State: EPA Local: Farm organizations	Same as above
TRANSPORTATION (Coal only)	Wind blown particulate containing trace contaminants	Residents along transportation corridor	(1-MD), -	Effect upon local biosystems	Damage suit, set standards	Federal: EPA, DOT State: EPA, DOT Local: Farm organizations	Require carriers to cover top of vehicle carrying coal.

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

NRC = Nuclear Regulatory Council
EPA = Environmental Protection Agency
DOT = Department of Transportation

3/3/77 bd

[illegible]

TABLE A - AIR QUALITY - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
CONVERSION Coal Gasification	Gaseous emissions and particulates containing trace contaminants	AC, L SV-MD, MC	AC,L,(SV-MD), MC	AC,L,(SV-MD), MC	--	AC,L,(SV-MD) MC	AC,L,(SV-MD), MC	--	BOM
Electrical Generation	Gaseous emissions and particulates containing trace contaminants	AC,L, (SV-MD), MC	AC,L,(SV-MD), (MC-SR)	AC,(SV-MD), (MC-SR)	1	AC,L,(SV-MD) (MC-SR)	AC,L,(SV-MD) MC	3	BOM
	Radioactive emissions	(VU-AI), L,SV, (MC-SR)	(VU-AI),L, SV,(MC-SR)	VU,L,SV, (MC-SR)	2	(VU-AI),L, SV,(MC-SR)	(VU-AI),L,SV, (MC-SR)	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

TABLE B - AIR QUALITY - 4

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
CONVERSION Coal Gasification	Gaseous emissions and particulate containing trace contaminants	Residents and farmers in the affected region	(MD-SV),-	Public health & local biosystems effects, climatological effects.	Damage suit, enforce standards set stronger standards injunction against operation under certain meteorlogical conditions.	Federal: EPA State: EPA Local: public health board, city gov'ts, environmental groups, farm organizations	Possible improvement in abatement technologies, migration of population from the most affected locations
Electrical Generation	As above	As above	As above	As above	As above	As above	As above
	Radioactive emissions	Residents and biosystems in region	SV, -	Depending on accident: death, long-term biological effects, long-term contamination of land	Many damage suits	Federal: EPA, NRC State: EPA, Nat'l Guard Local: City governments, environmental groups, civil defense groups	Moratoriaum on nuclear generation? Public fear on nuclear power; New designs to remove cause of accident; Survival of the nuclear industry.

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - CLIMATOLOGY - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
CONVERSION Electrical Generation	Increased precipitation due to particulate emissions	P,L,MD, (MC-R)	AC,L,SV, (MC-R)	P,L,MD,(LO-R)	1	P,L,(MD-S), (MC-R)	P,L,MD,(LO-R),	3	BOM
	Acid rainfall due to sulfur emissions	VL,M, MD,R	AC,M,SV,R	VL,M,SV,R	1	VL,M,SV,R	VL,M,MD,R	3	BOM
	Increased atmospheric humidity due to use of cooling towers for heat rejection	P,L,MD, MC	AC,(M-L),SV, SR	AC,(M-L),SV,R	2	P,L,MD,MC	VL,(M-L),SV,R	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - CLIMATOLOGY - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
<u>CONVERSION</u> Electrical Generation	Increased precipitation due to particulate emissions	Residents; Farmers; Highway maintenance personnel	(MD-SV),- (MD-SV),+* (MD-SV)	Change in climate due to increased precipitation could be beneficial to farmers. Roads harder to maintain. To general residents uncertain.	Force meeting of emission standards; set new standards	Fed. & State EPA; environmental groups	Improved technologies for particulate removal; residents move from region possible
	Acid rainfall due to sulfur emissions	Residents; Fish & game people; Farmers	(MD-SV),-	Increased acidity of ground & water within region effects on biological species, particularly plants	Damage suits; force meeting of emission standards; set new standards	As above plus Farm organizations, wildlife groups	Improved technologies for sulfur emissions removal use of low sulfur coal
	Increased atmospheric humidity due to use of cooling towers for heat rejection	Farmers; Local residents; Motorists	(SV-MD),-	Reduced visibility; effects on plants; possibly poorer drying of crops; less comfortable climate for local residents	Very little can be done, possible law suits	Fed. & State EPA; environmental groups	Develop technologies which allow less transfer of moisture to environment

*In times of drought, increased cloud seeding from particulates may be beneficial.

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

D.8 IMPACTS: WATER QUALITY AND HYDROLOGY

Increased activity projected by the four RTCs will affect water-related processes in two distinct fashions. Water quality is affected by increased extraction activity and the thermal degradation of water used as a cooling medium. Hydrologic changes occur due to perturbations in water runoff patterns and variations in flow patterns due to evaporative cooling. The following two sections address these two types of water related impacts separately.

D.8.1 ENVIRONMENTAL QUALITY IMPACTS (WATER)

Coal

The principal impacts of a coal-energy technology on water quality are the result of extraction processes (acid mine drainage), and of the ultimate conversion to electrical energy (thermal discharge). Since none of the scenarios under consideration utilizes once-through cooling, the thermal discharge impacts are negligible. Other impacts are also minor.

Surface extraction of coal (strip mining) leaves the land barren of vegetation and with material at fairly great angles of repose. Rainfall and surface runoff will carry quantities of this material as sediment into water courses, where it contributes to the turbidity of rivers and streams, and results in gradual filling of lakes and reservoirs. Soluble materials may be leached into the ground water. A major impact results from the oxidation of sulfur which, prior to mining, had been beneath the water table; ultimately, this leads to the production of sulfuric acid, and acidic conditions in nearby rivers and streams. Underground mining produces far less material which can be carried as a portion of the sediment load,

but underground mines must be kept dry, and the water which is pumped out of them is another source of acid mine drainage. Even after the mine is abandoned and pumping ceases, water which seeps through the mine will carry sulfuric acid with it, into rivers, lakes and wells.

The conversion of coal to electrical power by means of the steam cycle has, historically, been responsible for a major water quality change through thermal discharge. The condensation of steam, once it has passed through the generating turbines, requires a large quantity of cool water, which is then returned to the waterbody at a significantly elevated temperature. In many cases, this discharge has been poorly dispersed and has taken place at locations in a river which are particularly sensitive, and has, therefore, resulted in considerable ecological damage. In recent years, concern over this sort of damage has led to the use of atmospheric cooling towers, in which most of the heat is carried into the atmosphere in the form of water vapor. Although eliminating the heated discharge, evaporative cooling uses significant amounts of water, and has its own impact on the quality of waterbodies due to reduced flow for dilution of contaminants discharged into the water. In addition, it should be recognized that many biologists and others regard the heated discharge of once-through cooling, if properly designed and controlled, as a boon to the life of the receiving water rather than a detriment.

Coal conversion into gaseous forms is carried out principally to remove some of the more noxious pollutants in coal (sulfur) and to produce a fuel which is convenient to transport and use. Since gasification uses a significant amount of water for the production of hydrogen to combine with the carbon in coal, and some additional water for evaporative cooling of the

chemical reactions in the process which give off heat, its major impact on water quality is the reduction of flow for dilution. Gasification also produces a number of impurities, principally sulfur, ammonia, cyanide, trace metals and hydrocarbons, which may be discharged into the water if not adequately treated.

Table D.8-1 shows these impacts of coal technology on water quality, along with some others which are relatively insignificant.

Nuclear

A nuclear energy technology has the same major impacts on water quality, with the addition of the discharge of radioactive material. Acid mine drainage occurs from nuclear mining in much the same fashion as from coal mining, but in lesser degree. Once-through cooling can lead to heating of waterbodies from nuclear power generation just as from coal power generation, except that since nuclear generation is less efficient than coal generation, and since no heat is discharged into the atmosphere with combustion gases from nuclear generation, the thermal discharge to the water is greater than from coal power.

In addition to the impacts of conventional coal-energy technology, however, nuclear technology has the potential for the discharge of radioactivity to the environment. The principal points of impact with water quality are: at extraction (particularly if surface-mined), where runoff and leaching may carry radioactive materials (radium 226, in particular) into surface waterbodies or underground aquifers; during transportation, where an accident could discharge radioactive matter to the environment and ultimately into water supplies; and during discharge or permanent storage of spent fuels and collected waste matter from the reactor.

Policy

Three principal policy issues, all related to regulatory agencies, can be identified with respect to water quality.

A principal method of controlling the impact of mining on water quality will be the regulation of mining practices; but each new requirement increases the cost of the mined fuel and ultimately the cost of energy to the consumer. The extent to which such regulations should be imposed is a major policy question.

Decisions about the tradeoff between once-through cooling and evaporative cooling require careful investigation of the total impact of thermal discharge, part of which may be beneficial, and of evaporative cooling towers, which may constitute degradation of the environment in other ways.

The use of recirculative cooling through cooling ponds is also growing in areas where these ponds are possible. Evaporative losses from such ponds are smaller than from cooling towers, yet there is essentially no thermal discharge to natural waters. However, the extent to which the quality of discharges to such single-purpose, man-made waterbodies should be controlled is an issue which must be decided.

D.8.2 PHYSICAL IMPACTS (HYDROLOGICAL)

Coal

The hydrological impacts of coal-related energy functions occur in three categories: changes in runoff patterns due to surface mining; reduced flow due to evaporative cooling; and changes in flow patterns due to diversions for cooling purposes.

Strip mining leaves the land in ridges approximately 50-100 feet apart. This may result in entrapment of rainfall and delay of the time the water reaches a watercourse, thus reducing downstream flood peaks; or it may accelerate the water in its travel to a watercourse, and increase flooding downstream. The fact that the land is without vegetation will tend to decrease time of flow.

Evaporative cooling will cause reductions in flow quantities. It is evident that there is sufficient water within the ORBES region to supply all of the evaporative cooling needs reflected in any of the scenarios; however, when one explores the needs on a smaller scale than the whole region (at the single-county or few-county level), there are some locations where there is insufficient water. It is likely that such difficulties will be resolved by the shipment of cooling water over fairly short distances (perhaps up to 50 miles at most).

Nuclear

The impacts from nuclear-related energy functions are similar to those from coal. However, since the area of extraction is likely to be smaller, the impact of surface mining on flood peaks will be less (when taken nation-wide). Individual instances will, of course, be no different; there will just be fewer of them. On the other hand, since nuclear power generation

requires more cooling water, the impact of evaporative cooling and diversion is likely to be somewhat greater.

Policy

The major policy issue here, as in most other of the impact areas, is the set of decisions which select among the scenarios. Aside from this issue, the hydrological impacts suggest two others. The impact of surface mining on floods can be controlled by careful planning of the manner in which the land is mined and the spoils are replaced; but the most beneficial practices carry a higher price tag. Thus, the degree to which the practice of strip mining is to be regulated for flood protection remains as a policy issue. As in many other cases, there is an important need for research: it is not clear at this time to what extent good and poor strip mining practices may affect the magnitude of flood peaks.

A second policy issue, which is also mentioned in other sections of this report, relates to the use of once-through cooling as opposed to evaporative cooling. Since evaporative cooling, particularly by means of cooling towers, results in the loss of a significant quantity of water, it is possible that once-through cooling may be desirable in some instances.

REFERENCES

1. Beychok, M. R. Process and Environmental Technology for Producing SNG and Liquid Fuels. EPA-660/2-74-011. 1975.

2. Bonelieure, E. B. Industrial Waste Treatment. McGraw-Hill. 1952.

3. Clark, D. A. State-of-the-Art: Uranium Mining, Milling and Refining Industry. EPA 660/2-74-038. 1974.

4. Doyle, W. S. Deep Coal Mining: Waste Disposal Technology. Noyes Data Corp., Park Ridge, N. J. 1976.

5. Doyle, W. S. Strip Mining of Coal: Environmental Solutions. Noyes Data Corp., Park Ridge, N. J. 1976.

6. Environmental Analysis of the Uranium Fuel Cycle, Part I, Fuel Supply; Part II, Nuclear Power Reactors. EPA 520/9-73-003-B. 1973.

7. Freudenthal, D. F., P. Riccardelli and M. N. York. Coal Development Alternatives. Wyoming Department of Economic Planning and Development. 1974.

8. Gurnham, C. F. Principles of Industrial Waste Treatment. Wiley. 1965.

9. Hoglund, B. M. and J. G. Asbury. Potential Sites for Coal Conversion Facilities in Illinois. Illinois Institute of Environmental Quality Document 74-60. 1974.

10. Leonard, J. W. and D. R. Mitchell (eds.). Coal Preparation. American Institute Min., Met. and Pet. Engrs., N. Y. 1968.

11. Proceedings of the Workshop on Research Needs Related to Water for Energy. UILU-WRC-74-0093, Univ. of Illinois Water Resources Center. November, 1974.

12. Pryor, E. J. (ed.). Mineral Processing. Elsevier. 1965.

13. Vimmerstedt, J. P., J. H. Finney and P. Sutton. Effect of Strip Mining on Water Quality. PB217-872. 1973.

TABLE A - IMPACTS ANTICIPATED FROM COAL- AND NUCLEAR-RELATED ENERGY FUNCTIONS: ENVIRONMENTAL QUALITY (WATER) - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION Surface	Increased sediment content and turbidity (including radioactive matter)	AC,M,MD, SR	AC,M,MD,SR	AC,M,MD,SR	1	AC,M,MD,SR	AC,M,MD,SR	3	BOM
	Increased dissolved radioactivity	AC,L,MD, SR-N	AC,L,MD,SR-N	AC,L,MD,SR-N	2	AC,L,MD,SR-N	AC,L,MD,SR-N	4	BOM
	Filling(silting)of lakes & reservoirs	VL,M,MD, SR	VL,M,MD,SR	VL,M,MD,SR	1	VL,M,MD,SR	VL,M,MD,SR	3	BOM
	Decreased pH (acid mine drainage)	AC,L,SV, SR-ST	AC,L,SV,SR-ST	AC,L,SV,SR-ST	1	AC,L,SV,SR-ST	AC,L,SV,SR-ST	3	BOM
Underground	As above	As above	As above	As above	As above	As above	As above	As above	As above

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - ENVIRONMENTAL QUALITY (WATER) - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION Surface	Increased sediment & turbidity	Business, Landowners, Real estate, Recreation, League of Women Voters, Ad hoc, Municipalities, Environmental/ Recreational, Chamber of Comm.	-	Reclamation and mining controls		FEDERAL: BOM, Bur.Land Reclamation, Soil Cons.Ser., Environmental Prot.Agency, Coun.on Envn. Quality. STATE: Envr.Protect. Agency, BOM. LOCAL: Mun. Public Works	Reclamation and mining controls (economic)
	Increased dissolved radioactivity	As above	-			As above plus Nuc.Reg.Comm.	
	Silting of lakes and reservoirs	As above	-	As above		As above plus Corps of Engrs.	As above
	Decreased pH	As above plus Farmers	-	As above		As above	As above
Underground	As above	As above	-	As above		As above	As above

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

TABLE A - ENVIRONMENTAL QUALITY (WATER) - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
CONVERSION Electrical Generation	Increased water temperature	VU,L,MD, SR	VU,L,MD,SR	VU,L,MD,SR	2	VU,L,MD,SR	VU,L,MD,SR	4	BOM
	Increased concentrations of toxic chemicals (anti-fouling)	VU,L,I-MD,LO	VU,L,I-MD,LO	VU,L,I-MD,LO	2	VU,L,I-MD,LO	VU,L,I-MD,LO	4	BOM
	Increased concentrations of contaminants due to reduced flow	P,L,MD, LO	P,L,MD,LO	P,L,MD,LO	2	P,L,MD,LO	P,L,MD,LO	4	BOM
Low BTU Gasification	Increased concentrations of contaminants due to reduced flow	AI,L,I, SR	VU,L,I,SR	VU,L,I,SR	1	—	—	—	
High BTU Gasification	As above	As above	As above	As above	1	—	—	—	
	Increased amounts of S, NH_3, HCN, trace metals and hydrocarbons	AI,L,I, SR	AI,L,M,SR	AI,L,M,SR	1	—	—	—	

D.8-10

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - ENVIRONMENTAL QUALITY (WATER) - 4

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
CONVERSION Electrical Generation	Increased water temperature	Business, Landowners, Real estate, Recreation, League of Women Voters, Ad hoc, Municipalities, Environmental/Recreational, Chamber of Commerce	?	Once-through cooling Regulation of single-purpose reservoirs		FEDERAL: Federal Power Com., Council on Environ. Quality, Environmental Protection Agency, Fed. Energ. Admin. STATE: Equivalent agencies.	
	Increased toxic chemicals	As above	-			As above	
	Increased contaminants	As above	-			As above	
Low BTU Gasification	Increased contaminants	As above plus Farmers, Labor	-			FEDERAL: Environ.Protec. Ag., Fed. Energ. Admin., Coun.on Env. Quality. STATE: As above	
High BTU Gasification	As above	As above	-			As above	
	Increased amts. of S, NH_3, HCN, tr. metals and hydrocarbons	As above	-			As above	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

TABLE A - ENVIRONMENTAL QUALITY (WATER) - 5

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
TRANSPORTATION	Increased concentrations of contaminants due to accidental spillage	VU-P,M, I-MD,SR	VU-P,M,I-MD, SR	VU-P,M,I-MD, SR	1	VU-P,M,I-MD, SR	VU-P,M,I-MD, SR	3	BOM
Barge	Decreased quality due to barging activities	AC,L, I-MD,R	AC,L,I-MD,R	AC,L,I-MD,R	1	AC,L,I-MD,R	AC,L,I-MD,R	3	BOM
WASTE DISPOSAL	Radioactive contamination (spillage)	VU,M,SV, SR-R	VU,M,SV,SR-R	VU,M,SV,SR-R	2	VU,M,SV,SR-R	VU,M,SV,SR-R	4	BOM
UTILIZATION	Decreased quality due to increased urbanization and industrialization	AC,L,MD, SR	AC,L,MD-SV, SR	AC,L,MD-SV,SR	No dif.	AC,L,MD,SR	AC,L,MD-SV,SR	No dif.	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - ENVIRONMENTAL QUALITY (WATER) - 6

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
TRANSPORTATION	Increased concentrations of contaminants	Business, Landowners, Farmers, Real Estate, Recreation, Ad hoc, League of Women Voters, Chamber of Com., Environmental/Recreational	-			FEDERAL: Environmental Prot. Agency, Council on Environ. Quality, Dept. of Transportation. STATE: Equivalent state agencies	
Barge	Decreased quality	As above	-			As above	
WASTE DISPOSAL	Radioactive contamination	All parties	-			FEDERAL: Nuc. Reg. Comm., Council on Env. Quality, Env. Protection Agency. STATE: As above	
UTILIZATION	Decreased quality	Business, Landowners, Farmers, Real Estate, Recreation, Ad hoc, League of Women Voters, Chamber of Com., Environmental/Recreational	-			FEDERAL: Council on Environmental Quality, Environmental Protection Ag. STATE: As above	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

TABLE A - IMPACTS ANTICIPATED FROM COAL- AND NUCLEAR-RELATED ENERGY FUNCTIONS: PHYSICAL (HYDROLOGY) - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION Surface	Changes in runoff pattern, probably by entrapping run-off, increasing time of concentration and decreasing flood peaks. Lack of vegetation probably overcomes this gain for short term.	AC,L, I-MD,MC	AC,L,MD,MC	AC,L,I-MD,MC	1	AC,L,I-MD, MC	AC,L,I-MD,MC	3	BOM
CONVERSION Electrical Generation	Reduced flow due to evaporative cooling. Reduced and increased flow due to diversion.	AC,L, I-MD,SR	AC,L,I-MD,SR	AC,L,I-MD,SR	2	AC,L,I-MD, SR	AC,L,I-MD,SR	4	BOM
Low & High BTU Gasification	Reduced flow due to consumption	AC,L,I, MC	AC,L,I-MD,MC	AC,L,I-MD,MC	1	None	None	—	BOM
UTILIZATION	Increased impervious area resulting from urbanization and industrialization	AC,L,MD, SR	AC,L,MD,SR	AC,L,MD,SR	—	AC,L,MD,SR	AC,L,MD,SR	—	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - IMPACTS ANTICIPATED FROM COAL- AND NUCLEAR-RELATED ENERGY FUNCTIONS: PHYSICAL (HYDROLOGY) - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION Surface	Changes in run-off pattern	Business groups, especially real estate, Farmers, Landowners, Ad hoc groups, Chamber of Comm., Environ. groups, Recreation ind., General public	I-SV ?		Reclamation regulation Active mining regulation	FEDERAL: Corps of Engineers; Council on Environmental Quality; Environmental Protection Agency; BOM; Nuc. Reg. Com STATE: Dept. of Mines & Minerals; Environmental Protection Agency	
CONVERSION Electrical Generation	Reduced flow	As above	-	Quality impacts, navigation	Once-through cooling	As above	
Low & High BTU Gasification	Reduced flow	As above	-			As above	
UTILIZATION	Increased impervious area	As above	?			As above	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

D.9 IMPACTS: LAND QUALITY AND GEOMORPHOLOGY

Land quality, as used herein, is limited to consideration of land areas used for waste disposal and land areas affected by by-products of conversion processes. Land quality considerations from the perspective of geomorphology and land use are treated in separate sections. Solid waste will be produced in association with virtually every energy-related function except transportation. However, solid wastes can be released to the environment during transport.

Conversion of coal into electricity will produce large quantities of waste. Surface mining will generate about 1.2 tons of overburden waste for every ton of coal recovered from the ground (1). Underground mining will produce about 0.036 tons of solid waste for every ton of coal produced (1). Coal cleaning produces up to about 0.30 tons of solid waste per ton of washed coal (1). A steam-electric generating plant will produce about 0.12 tons of ash (recovered fly ash and bottom ash) per ton of coal burned (1). If wet lime scrubbing is used as the means of stack gas cleaning, about 0.25 tons of dry scrubber waste (including ash) will be produced for every ton of coal converted to electricity (2). This amounts to about 1.75 tons of waste per ton of coal if the coal comes from strip mines and scrubbers are used. The comparable figure for underground coal is 0.91 tons of solid waste per ton of coal.

In most cases, these wastes will be permanently stored near the site where they are produced. Mining and cleaning wastes can generally be graded back into the mined areas or otherwise treated and stored near the mining site. Scrubber sludge disposal requires a specially constructed pond near the generation station. A 1,000 MWe plant requires a 30-foot-deep disposal area covering about 80 acres to store the scrubber sludge produced over a

30-year period of plant generation (2, p. 1d-24). Procedures for returning these areas to productive uses are available.

Land quality may also be degraded over large areas surrounding coal-fired generating stations as airborne pollutants settle to the ground. The manifestation of this impact is in the form of reduced biological productive capability of the soil (see Biological/Ecological impact section). This impact can be ameliorated by control of stack gas emissions.

The amount of solid waste resulting from the nuclear fuel cycle affecting land quality in the ORBES region is much less than that expected from coal. It is highly unlikely that uranium ore will be mined in the region by the year 2000; therefore, extraction is not considered. Nuclear fuel is fabricated in the region but the amount of waste is small. Long-term storage of irradiated water, especially in the absence of reprocessing capability, poses substantially greater problems. Long-term storage will be accomplished by concentrating these wastes at regional waste disposal sites.

The ORBES region already has a storage facility for low-level wastes, and the region is being investigated as a candidate for a high-level waste repository. Although the amount of waste is small, the potential for land quality degradation is serious if confinement is incomplete. Accidental releases of radioactive material at the generating site or in transport also pose a serious threat to land quality. However, as Table D.9-1 indicates, these events have a low probability of occurance.

Definite conclusions about the relative severity of land quality impacts from the high-nuclear RTCs and the high-coal RTCs are not possible. Coal development within the region is certain to result in widespread degradation of land quality. It is just as certain that land quality degradation from coal development can be kept within acceptable limits through application of existing technology. Land quality impacts from nuclear de-

velopment are not as certain. If existing technology is applied correctly to nuclear development, the land quality impacts will be localized and relatively insignificant. However, the potential for land quality degradation is immense if some unforeseen natural or man-induced hazard intervenes to negate the safety precautions built into the nuclear program. The BOM RTCs have much more serious land quality implications than the Tech Fix RTCs.

Geomorphological impacts will result from all coal- and nuclear-related functions. The impacts considered here are those associated with reshaping the landscape and attendant disruption of drainage patterns, sedimentation rates and erosion rates. Land areas directly subject to these impacts are the same as those areas subject to land use changes (see Table D.9-1). For the functions of conversion, transportation and utilization, geomorphological impacts will be most obvious and severe during the construction phase of development. Assuming the application of generally accepted civil engineering practices, impacts resulting from these functions should be reduced to acceptable levels during the operational phase.

Geomorphological impacts from extraction, processing and waste disposal are of greater concern. For these functions, production of waste materials and direct modification of the shape of the land will occur on a continuing basis. Surface extraction of coal will certainly result in large piles of unstable waste materials and disruption of surface drainage, and possibly, disturbance of aquifer flow. In addition to these impacts, subsidence must be listed as a significant impact of underground mining. Beyond the obvious deformation of surface features resulting from subsidence, the possibility of disruption of all drainage systems, including tile drainage on agricultural land must be considered.

Possible off-site impacts of these geomorphological changes are additional sources of concern. Disruption of surface and underground flows of water affecting downstream users has already been noted. Increased drainage density, reduced surface permeability and reduced vegetative cover resulting from conversion and utilization could cause changes in surface flow

intensity affecting erosion and deposition rates at downstream locations.

A comparison of geomorphological impacts between RTCs is given in Table D.9-2. In general, these impacts will be greater for the RTCs having more coal-fired generating stations. The BOM RTCs will clearly have more severe geomorphological impacts than the Tech Fix RTCs. Policy options capable of reducing the severity of these impacts include zoning or land use planning to limit development to relatively insensitive areas and regulations to ensure timely and effective land reclamation for controlling impacts after occurrence of the land disturbance (Table D.9-2).

REFERENCES

1. Wilson, R. and Jones, W., Energy, Ecology, and the Environment, New York: Academic Press, Inc., 1974.

2. ORBES Task I Report, October 18, 1976.

TABLE A - ENVIRONMENTAL QUALITY (LAND) - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION	Presence of spoil and gob piles on land--unstable piles of waste material--low aesthetic appeal	AC,(S-L) SV,LO	AC,(S-L),SV, LO	AC,(S-L),SV,LO	1	AC,(S-L), SV,LO	AC,(S-L),MD,LO	3	BOM
PROCESSING COAL	Refuse piles on land	AC,(S-L), MD,LO	AC,(S-L),MD, LO	AC,(S-L),MD,LO	1	AC,(S-L), MD,LO	AC,(S-L),MD,LO	3	BOM
NUCLEAR	As above	AI,(S-L) MD,LO	VU,(S-L),MD, LO	P,(S-L),MD,LO	2	AI,(S-L), MD,LO	P,(S-L),MD,LO	4	BOM
CONVERSION COAL	Airborne pollutants settling on land	AC,L, (I-MD), SR	AC,L,(I-MD), SR	AC,L,(I-MD),SR	1	AC,L,(I-MD), SR	P,L,(I-MD),SR	3	BOM
NUCLEAR	Radioactive contamination of land	AI,L,SV, MC	AI,L,SV,MC	VU,L,SV,MC	2	AI,L,SV,MC	VU,L,SV,MC	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - ENVIRONMENTAL QUALITY (LAND) - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION	Presence of spoil & gob piles on land--unstable piles of waste material--low aesthetic appeal	Farmers, Landowners, Real estate industry Business, Recreation ind., Recreationists Environmentalists Ad hoc groups	M, - M, + or - M-SV, - SV, -	Effectiveness of land reclimation	Reclimation legislation; Bonding authority, Land use planning & zoning	Federal: Courts, Congress State: Courts, Legislation Local: Courts, Planning & Zoning Bd.	
PROCESSING COAL AND NUCLEAR	Refuse piles on land	As above	As above	As above	As above	As above	
CONVERSION COAL	Airborne pollutants settling on land	As above	As above	Emission standards	Enforce or strengthen emission standards	As above plus Federal: EPA State: EPA	
NUCLEAR	Radioactive contamination of land	As above	As above	Reliability of confinement procedures & mechanisms	Change safety standards	As above plus Federal: NRC	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - ENVIRONMENTAL QUALITY (LAND) - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
TRANSPORTATION COAL	Loss of coal in transport	AC,L,I, LO	AC,L,I,LO	AC,L,I,LO	1	AC,L,I,LO	AC,L,I,LO	3	BOM
NUCLEAR	Loss of uranium in transport	AI,L,SV, MC	AI,L,SV,MC	VU,L,SV,MC	2	AI,L,SV,MC	VU,L,SV,MC	4	BOM
WASTE DISPOSAL COAL	Piles of ash, scrubber sludge & refuse on land	AC,L, MD,LO	AC,L,MD,LO	AC,L,MD,LO	1	AC,L,MD,LO	AC,L,MD,LO	3	BOM
NUCLEAR	Radioactive contamination of surrounding land	VU,L, SV,LO	VU,L,SV,LO	P,L,SV,LO	2	VU,L,SV,LO	P,L,SV,LO	4	BOM
UTILIZATION	Land storage of the full range of waste products resulting from utilization of energy	AC,L, SV,MC	AC,L,SV,MC	AC,L,SV,MC	N	VL,L,MD,MC	VL,L,MD,MC	N	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - ENVIRONMENTAL QUALITY (LAND) - 4

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
TRANSPORTATION COAL AND NUCLEAR	Loss of fuels in transport	Farmers, Landowners, Real estate industry Business, Recreation ind., Recreationists Environmentalists Ad hoc groups	M, - M, + or - M-SV, - SV, -	Confinement of fuels in transport	Tighten or enforce transportation regulations	Federal: Courts, Congress, ICC, Federal Trade Comm. State: Courts, Legislation Local: Courts, Planning & Zoning Bd.	
WASTE DISPOSAL COAL	Piles of ash, scrubber sludge as refuse on land	As above	As above	Confinement of leachate, reclimation procedures	Tighten or enforce confinement & reclimation	Federal: EPA, Courts, Congress State: Courts, Legislation, EPA Local: Courts	
NUCLEAR	Radioactive contamination of surrounding land	As above	As above	Enforcement & adequacy of confinement	Tighten or enforce confinement regulations	As above plus Federal: NRC	
UTILIZATION	Land storage of full range of waste products resulting from utilization of energy	All parties are potentially interested	Depends on perception of impact (SV to I), (+ to -)	Where and how to store wastes	Zoning, land use planning, regulation of waste storage	All agencies are potentially responsive	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - GEOMORPHOLOGY - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION COAL Surface	Remaking landscape, disruption of drainage pattern, creation of new drainage lines & attendant changes in pattern, intensity & distribution of geomorphological processes (e.g., erosion & sedimentation). Problems could occur off-site (e.g., disruption of aquifier flow).	AC, (S-L) SV, (LO-MC)	AC, (S-L), SV, (LO-MC)	AC, (S-L), SV, (LO-MC)	1	AC, (S-L), SV, (LO-MC)	AC, (S-L), SV, (LO-MC)	3	BOM
Underground	As above plus subsidence	AC, L, SV, LO	AC, L, SV, LO	AC, L, SV, LO	1	AC, L, SV, LO	AC, L, SV, LO	3	BOM
NUCLEAR Surface & Underground	As above	AI, L, SV, LO	AI, L, SV, LO	VU, L, SV, LO	2	AI, L, SV, LO	VU, L, SV, LO	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - GEOMORPHOLOGY - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION COAL AND NUCLEAR Surface	Remaking landscape, disruption of drainage pattern, creation of new drainage lines & attendant change in pattern, intensity & distribution of geomorphological processes (e.g., erosion & sedimentation). Problems could occur off-site.	Landowners Farmers Environmentalists Recreationists Ad hoc groups Public agencies (municipal water supply officials) Agricultural organizations Real estate industry Recreation industry	(SV-I),-	Effectiveness of reclimation procedures, Avoidance of particularly sensitive areas	Creating, tightening or enforcing reclimation laws; Land use planning, zoning	Federal: Courts, Congress State: Courts, Legislation Local: Courts, Planning & Zoning Bd.	
Underground	As above plus subsidence	As above	As above	As above	As above	As above	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - GEOMORPHOLOGY - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
PROCESSING COAL	Remaking landscape, disruption of drainage pattern, creation of new drainage lines & attendant changes in pattern, intensity & distribution of geomorphological processes (e.g., erosion & sedimentation). Problems could occur off-site (e.g., disruption of aquifier flow).	AC,L,I, LO	AC,L,I,LO	AC,L,I,LO	1	AC,L,I,LO	AC,L,I,LO	3	BOM
NUCLEAR Milling	As above	AI,L,I, LO	VU,L,I,LO	P,L,I,LO	2	AI,L,I,LO	VU,L,I,LO	4	BOM
Enriching & Fabricating	As above	AC,L, MD,LO	AC,L,MD,LO	AC,L,MD,LO	2	AC,L,MD,LO	AC,L,MD,LO	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - GEOMORPHOLOGY - 4

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
PROCESSING COAL AND NUCLEAR All Subfunctions	Remaking landscape, disruption of drainage pattern, creation of new drainage lines & attendant change in pattern, intensity & distribution of geomorphological processes (e.g., erosion & sedimentation). Problems could occur off-site.	Landowners Farmers Environmentalists Recreationists Ad hoc groups Public agencies (municipal water supply officials) Agricultural organizations Real estate industry Recreation industry	(SV-I), -	Avoidance of particularly sensitive areas	Land use planning, zoning	Federal: Courts, Congress State: Courts, Legislation Local: Courts, Planning & Zoning Bd.	

WORKING DRAFT

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - GEOMORPHOLOGY - 5

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
CONVERSION COAL AND NUCLEAR	Remaking landscape, disruption of drainage pattern, creation of new drainage lines & attendant changes in pattern, intensity & distribution of geomorphological processes (e.g., erosion & sedimentation). Problems could occur off-site (e.g., disruption of aquifier flow).	AC,L, MD,LO	AC,L,MD,LO	AC,L,MD,LO	2	AC,L,MD,LO	AC,L,MD,LO	4	BOM
TRANSPORTATION COAL AND NUCLEAR	As above	AC,L, I,LO	AC,L,I,LO	AC,L,I,LO	?	AC,L,I,LO	AC,L,I,LO	?	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - GEOMORPHOLOGY - 6

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
CONVERSION COAL AND NUCLEAR	Remaking landscape, disruption of drainage pattern, creation of new drainage lines & attendant change in pattern, intensity & distribution of geomorphological processes (e.g., erosion & sedimentation). Problems could occur off-site.	Landowners Farmers Environmentalists Recreationists Ad hoc groups Public agencies (municipal water supply officials) Agricultural organizations Real estate industry Recreation industry	(SV-I), -	Avoidance of particularly sensitive areas	Land use planning, zoning	Federal: Courts, Congress State: Courts, Legislation Local: Courts, Planning & Zoning Bd.	
TRANSPORTATION COAL AND NUCLEAR	As above	As above	As above	As above	As above	As above	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

D.9-16

3/3/77 bd

TABLE A - GEOMORPHOLOGY - 7

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
WASTE DISPOSAL COAL All Subfunctions	Remaking landscape, disruption of drainage pattern, creation of new drainage lines & attendant changes in pattern, intensity & distribution of geomorphological processes (e.g., erosion & sedimentation). Problems could occur off-site (e.g., disruption of aquifier flow).	AC,L,I, LO	AC,L,I,LO	AC,L,I,LO	1	AC,L,I,LO	AC,L,I,LO	3	BOM
NUCLEAR All Subfunctions	As above	P,L,I, LO	P,L,I,LO	P,L,I,LO	2	P,L,I,LO	P,L,I,LO	4	BOM
UTILIZATION COAL AND NUCLEAR	As above	AC,L, SV,N	AC,L,SV,N	AC,L,SV,N	N	VU,L,SV,N	VU,L,SV,N	N	BOM

D.9-17

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - GEOMORPHOLOGY - 8

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
WASTE DISPOSAL COAL AND NUCLEAR All Subfunctions	Remaking landscape, disruption of drainage pattern, creation of new drainage lines & attendant change in pattern, intensity & distribution of geomorphological processes (e.g., erosion & sedimentation). Problems could occur off-site.	Landowners Farmers Environmentalists Recreationists Ad hoc groups Public agencies (municipal water supply officials) Agricultural organizations Real estate industry Recreation industry	(SV-I), -	Effectiveness of reclimation procedures, Avoidance of particularly sensitive areas	Land use planning, zoning	Federal: Courts, Congress State: Courts, Legislation Local: Courts, Planning & Zoning Bd.	
UTILIZATION COAL AND NUCLEAR	As above	All parties are potentially interested	Depends on perception of impact (SV to I), (+ to -)	As above	As above	As above	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

D.10 BIOLOGICAL AND ECOLOGICAL IMPACTS

The significant biological and ecological impacts of the range of electrical production activities are listed in Table D.10-3 at the end of this section. In characterizing the impacts for the scenarios, the impacts of a single process or site is generalized. To make distinctions between the two fuel mixes to the year 2000 a subjective estimate of the probability of occurrence and the aggregate effects are used. Parties at interest, with some exceptions, are those groups that would be subjected directly to the impact. These impacts tend to flow from an assessment of the enhancement or degradation of the quality of biological and ecological uses of the land.

EXTRACTION

Surface mining of fuel (coal or nuclear) necessarily destroys existing plant and animal communities. For natural systems the result is their replacement with bare ground. As reclamation begins, new uses of the land may follow. For example, if natural vegetation is fostered, a young sere will be established that will be a suitable habitat for upland game. Thus a secondary impact of strip mining is to potentially increase the amount of area available to hunters. However, the time required for natural revegetation, measured in decades, may be unacceptably long.

If the area to be strip mined is productive for agricultural or forest products, its annual yield will be lost, perhaps forever, or at least until some future date. Since the supply of productive soils is finite, and since demand for its products generally lags population growth, the full impact of the loss of productive lands may not be realized until some time in the future.

Strip mining and deep mining will have a detrimental effect on surface waters through siltation and acid drainage and will reduce the habitat available to aquatic populations. This will result in an overall decline in productivity.

Deep mining and concomitant surface subsidence will have an adverse effect on surface drainage. Without corrective measures, the surface communities will be altered, and agricultural lands will become less productive.

With the mining activity implied for all scenarios, it is likely that significant sites will be threatened. A significant site is one that has unusual ecological, historical and/or archaeological value.

Parties at Interest

The impacted parties from fuel extraction will include people who use land for recreation and agriculture, environmentalists and scholars as well as urban dwellers near minable land. The consuming public will also be affected. The potential recreational gains from strip mining would likely be offset by losses of recreational areas. The overall quality of recreational land is likely to go down in the short term. Those with agricultural interests would be faced with higher land cost caused by reduced supply. Water utilities would face potentially higher costs in water purification because of higher sediment loads and reduced water pH. Consumers could face higher food costs through decreased supply of agricultural land.

The response of agricultural and recreational parties to proposed strip mining would be expressed through existing interest groups such as the Grange, Farm Bureau, National Wildlife Federation, Sierra Club and

ad hoc groups. Their options would be to lobby for enactment of state or federal strip mining laws or strict enforcement of existing laws. Action by state fish and wildlife agencies and water utilities would vary according to their available options. Little or no action would be anticipated by consumer groups.

If a significant area is threatened through mining activity, strong resistance can be expected from environmentalists and scholars and appropriate state agencies. Their first avenue of opposition will likely be through court action. If this method is inadequate they can be expected to press for additional legal protection for areas with great intrinsic value.

Policy Options:

1. Future land use

The central issue regarding strip-mined land is its projected use. With areas that have great intrinsic or agricultural value, the question is whether this land should be mined at all.

For areas subjected to surface mining, policy options are limited to deciding future use of the land which may not be satisfactory to all impacted parties. Consumers, county governments and in some cases recreationists would like the land reclaimed in some manner suitable for recreation. One possible option is to allow the mined areas to be revegetated and lie fallow for a period of years before being returned to productive agriculture. The long term benefits of this option may be best for all parties.

Areas with great intrinsic value are in general protected by law. If they are threatened, their protection can be achieved through court actions. Valuable agricultural land is at present protected at the county level

through county zoning where such zoning exists. This land can be protected throughout by state zoning which would prohibit surface mining, or by federal law which would require that land be returned to its previous productivity. It should be pointed out, however, that at present such laws are in the early process of development and implementation.

Agricultural interest can seek relief from damages suffered from drainage impairment through court action. Mining companies can be held legally responsible to repair damages to drainage systems. However, the land may continue to subside after the mining company's responsibility has terminated. One possibility to compensate for this would be to assess a severence tax on deep mined coal and allocate that tax to drainage districts for repair and maintenance of subsurface drainage systems.

2. Protection of surface water

The sediment load from surface mining can be reduced or controlled by requiring sediment screens, strips of vegetation near streams and rapid revegetation of mined areas. Buffer zones of vegetation would be beneficial in reducing acid runoff. The sediment load from deep mines can be reduced by the use of sedimentation ponds. Water treatment may be required to decrease the acidity of the drainage water. Another option is to deny discharge into surface waters and levy fines against violators which would be used to rehabilitate damaged waters.

PROCESSING

Significant amounts of SO_x, NO_x and fluorides are released during processing and enrichment of nuclear fuels. The estimated annual emissions for a 1000 MW facility operated at 100% capacity, in metric tons, are, respectively, 23, 39 and 1.2 (7). These materials and especially fluorides

are toxic to living things. These pollutants will be released near ground level exacerbating the problem.

Because two of the three enrichment facilities are located in the ORBES region, Portsmouth, Ohio and Paducah, Kentucky, the national use of nuclear fuels will have an adverse effect on these locations. The estimated emissions for the year 2000, assuming 50% capacity and equal amounts of processing at each location are listed in Table D.10-1.

TABLE D.10-1

ESTIMATED EMISSIONS OF SO_X, NO_X AND FLUORIDES FROM NUCLEAR FUELS PROCESSING

Scenario	Number of nuclear generation plants in the U.S.	Emissions (tons/year/location) SO_X	NO_X	Fluorides
BOM 80:20	175	670	1100	35
BOM 50:50	493	1900	3200	98
Ford Tech Fix 100% Nuclear	100	390	660	20

Electrical plants in existence in 1985 are not included in these estimates. These estimates assume that 16% of the total electrical production occurs in ORBES and that the national fuel mix is identical to the ORBES region. The estimated emissions are sufficient to cause concern over possible losses to plants and damages to wildlife and domestic animals.

Parties at Interest

Landowners, including farmers and the general public are impacted parties. Property owners who suffer loss or damages are likely to seek compensation. The general public is likely to request additional controls on emissions.

Policy Options

Are emission standards adequate or enforced? A primary policy option is to require more stringent enforcement of emission standards if enforcement is lax. If existing standards are inadequate to maintain acceptable air quality, new standards may be implemented. If these options prove inadequate to prevent damages, impacted parties may seek relief and/or compensation through litigation.

CONVERSION

Vegetation can be damaged and/or killed from exposure to SO_2, O_3, NO_x and heavy metal emissions from electrical conversions. These impacts will be highly localized and specific to certain plants. Agricultural crops like alfalfa and tobacco can be expected to be damaged. The extent of the damage will be proportional to the exposure. If the exposure of natural communities is sufficiently high, productivity will decrease and existing communities will be replaced by several younger ones (8).

The impacts of acid rainfall on ecosystems are not well understood at this time, but potentially, they are numerous and complex (4). Anticipated ecological effects from acid rain include changes in the leaching rates of canopies and soils, alteration of predator-prey relationships, acidification of surface waters, changes in metabolism rates of organisms (3) and decreased growth rates of forests (6, 9). The leaching of terrestrial systems could also increase the eutrophication of surface waters. If the buffering capacity of the terrestrial systems is insufficient, the acidity of surface waters will increase and a decline in the sport fisheries will result.

The greatest impacts of acid rainfall will occur downwind and probably

out of the ORBES region. Based on information given by Johnson, Reynolds and Likens (3), the greatest impacts will be in the Northeastern Appalachian mountains.

The number and distribution of coal fired boiler facilities (CFBs) for each of the BOM scenarios raise serious questions about future air quality if present emission standards are used. Augemental air standards for class 1 areas are likely to be violated throughout the ORBES region. The concentration of CFBs along the Ohio River is likely to have severe impacts on that region. Plants, including ornamentals, rare and endangered species, common garden varieties, horticultural and agricultural species, are likely to be damaged or killed. Certain types of agriculture will be driven from the region. General productivity of the area is likely to decline due to deposition of acidic materials. The impact on animal life will be no less severe. Important historical sites are likely to be damaged through the corrosive action of SO_2-related materials.

Contamination by Radioactive Materials

Nuclear facilities are assumed to pose a small but real threat of contaminating the environment with radioactive materials. If the threat to humans is sufficient to preclude their location in populated areas, then they must also present a threat to adjacent ecosystems. If the radiation is severe the system will revert to younger successional stages (8). Little is known of the long range effects of low-level exposure.

Parties at Interest

Agricultural, recreational, environmental and ad hoc groups are the private interest groups that will probably respond to environmental impacts of coal conversion. Those farmers adjacent to plants who suffer damage

would respond with threat of or actual litigation. Environmental, recreational and ad hoc groups are expected to appeal to appropriate state or federal agencies to enforce existing laws or to implement new legislation. If satisfaction is not obtained, they may enter into litigation to at least enforce existing legislation. Federal and/or state agencies can use their authority to enforce emission standards or to levy fines to correct the damages.

WASTE DISPOSAL

Heat

Impacts of electrical generation on aquatic systems include: thermal effects, impingement and entrainment. Impingement and entrainment are not expected to be of major consequence.

The emphasis that has been given to thermal damage has focused on small streams that could not disperse the heat load (1). In the ORBES region, however, game fish yields will probably be improved by heated water. Cooling waters enhance sport fishing on small reservoirs by lengthening the fishing season and concentrating the fish in the discharge waters during cooler months. Growth rates of fish are also greater in heated waters. The cause for the difference in growth rate is unknown, although Coutant (1) suggests that it could be due to temperature effects or to discharge currents disrupting summer stratification. Another possible reason is the longer growth period in heated water.

Waste heat can be effectively utilized through multipurpose cooling reservoirs (1). New recreational areas can be created, although at the expense of existing land use, and most of the deleterious effects associated with waste heat can be avoided.

Cooling towers discharge chlorine and anticorrosive agents into the atmosphere. These materials can have a deleterious effect on the surrounding ecosystems. Cooling towers require makeup water which decreases stream flow and diluting capacity as well as discharging of toxic materials and anticorrosive agents. These materials can cause fish kills and increase eutrophication of streams and other surface waters.

Parties at Interest

Recreational groups, ad hoc groups and federal or state agencies are the impacted parties from fish kills or eutrophication of surface waters. All groups would be expected to react in the same manner as above.

Policy Options:

1. Are standards adequate or enforced?

One option always available to impacted or damaged parties is to sue for relief or compensation. Agencies responsible for setting and enforcement of standards may fine or shut down violators. If air quality cannot be maintained, responsible agencies may require a dispersed siting policy and/or smaller plants as opposed to the BOM scenarios. With the number of CFBs implied under the BOM new emission standards may have to be imposed. The central questions raised in regard to nuclear generators are:

How safe are they?

How will spent fuels be recycled?

How will radioactive waste be disposed of?

The policy options are to rigidly enforce existing standards or to adopt new standards and enforce them. Safe methods to recycle fuels must be developed and storage methods must be found. Another option that has been

suggested is to declare a moritorium on future nuclear development until these problems have been solved.

2. What is the best method of disposing of waste heat?

The present options are to use cooling towers or cooling reservoirs. Reservoirs should be cheaper to build and maintain and also have the advantage of presenting new recreational areas. However, they are a larger user of land than cooling towers. Through judicious siting, this negative aspect of reservoirs can be prevented.

COMPARISON OF SCENARIOS

The qualitative comparisons of Table D.10-3, indicate that BOM 80:20 has greater impacts than BOM 50:50; that Ford Tech Fix 100% coal has greater impacts than 100% nuclear; and that the BOM scenarios have greater impacts than the Ford Tech Fix. These comparisons are based largely on the anticipated impacts of energy production with coal and places little weight on radiation hazards of nuclear fuels.

The estimated annual emissions of SO_2 of particulates, and of NO_x for the years 1975 and 1985 within the context of the four scenarios are compared in Table D.10-2. For 1975 and 1985, coal and oil are assumed to have the same emission rates per 1000 MW(E) as follows:

SO_2	7.4×10^4 tons/year
Particulates	4.3×10^3 tons/year
NO_x	2.8×10^4 tons/year

For installations after 1975, new source standards are assumed. An efficiency of 37% (5) and an average capacity of 50% are also assumed in these estimates.

TABLE D.10-2

ESTIMATED YEARLY EMISSIONS OF SO_2, PARTICULATES AND NO_x

Year	Emissions (Tons/year) SO_2	Particulates	NO_2
1975	4.3×10^6	2.4×10^5	1.6×10^6
1985	4.9×10^6	2.9×10^5	1.9×10^6
2000			
BOM 80:20	6.8×10^6	4.7×10^5	3.2×10^6
BOM 50:50	5.8×10^6	3.8×10^5	2.6×10^6
Ford Tech Fix			
100% Coal	4.4×10^6	2.7×10^5	1.8×10^6
100% Nuclear	4.1×10^6	2.4×10^5	1.6×10^6

Based on these assumptions, the air quality will deteriorate slightly by 1985. Either of the BOM scenarios will cause significant deterioration of air quality by the year 2000. The Ford Tech Fix 100% coal will result in a slight reduction of emission over 1985 levels, but emissions will be slightly in excess of 1975 levels. The Ford Tech Fix 100% nuclear scenario has emissions of NO_x and particulates similar to 1975 levels, and the estimated emissions for SO_2 are slightly below 1975 levels. Based on these comparisons, the Ford Tech Fix 100% nuclear has the least impacts and would be preferable.

Natural systems are expected to absorb and somehow detoxify man-made pollutants. When the input of toxic materials to a system exceeds the capacity to detoxify these materials, the system will deteriorate. There is ample evidence that this capacity is being approached or exceeded for much of the nation east of the Mississippi River (3, 4, 5, 6, 9). The SO_2 emissions of much of the Ohio River Valley and the State of Ohio exceed 20 tons/km^2 (4), and the pH of rainfall is less than 5.0 for much of the ORBES region and the Northeast (3, 4). This implies that the present emission standards are inadequate and that more stringent standards must be set to reduce total SO_2 and NO_x emissions below present levels.

The use of taller stacks and/or a dispersed site are insufficient to meet these goals. These policies only serve to make the impacts more equitable. To achieve the goal of a reduction the total emissions of SO_2 and NO_x, existing facilities must reduce emissions through coal cleaning and/or retrofitting scrubbers, and new source standards must be more stringent. These policies will undoubtedly increase the cost of electricity and reduce demand. The reduction in demand should further reduce emissions.

In the past electrical energy supply has been governed by demand. This

policy needs reevaluation and changing at least until total emissions of acid producing materials are reduced.

Our total use of electrical energy should be evaluated to identify areas where consumption can be reduced. Luxury usage of electrical energy should be identified and possibly eliminated. Areas where conservation is possible should be identified and policies should be adopted to encourage conservation.

The total impact of coal-fired plants, from mine drainage to acid rainfall, cannot be over-emphasized. We are not only deteriorating our natural systems, but are damaging the heritage of future generations.

REFERENCES

1. Coutant, Charles C. How to Put Waste Heat to Work. ES&T 10:868-871. 1976.

2. Johnston, Noye M., Robert C. Reynolds and Gene E. Likens. Atmospheric Sulfur: Its Effect on the Chemical Weathering of New England. Science 177:514-516. 1972.

3. Likens, Gene E. and F. Herbert Bormann. Acid Rain: Serious Regional Environmental Problem. Science 184:1176-1179. 1974.

4. National Academy of Science. Mineral Resources and The Environment. 1975.

5. Palmedo, Philip F. The Use of Models in the Assessment of Energy Research and Development Options. In Energy and Environment Organization for Economic Cooperation and Development. Paris, France. 1974.

6. Whittaker, R. H., F. H. Bormann, G. E. Likens and T. G. Siccama. The Hubbard Brook Ecosystem Study: Forest Biomass and Production. Ecol. Monogr. 44:233 252. 1974.

7. Wilson, R. and W. J. Jones. Energy, Ecology and The Environment. New York: Academic Press. 1974.

8. Woodwell, G. M. Effects of Pollution on the Structure and Physiology of Ecosystems. Science 168:429-433. 1970.

9. Woodwell, G. M. Biotic Energy Flow. Science 183:867. 1974.

TABLE A - IDENTIFICATION AND CHARACTERIZATION OF BIOLOGICAL AND ECOLOGICAL IMPACTS - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION									
Both	Aquatic habitat destruction								
	1.Sedimentation	AC,L,SV, MC	AC,L,SV,SR	AC,L,SV,SR	1	AC,L,SV,MC	AC,L,SV,MC	3	BOM
	2.Acid drainage	"	"	"	1	"	"	3	BOM
PROCESSING	Gaseous damage to plants	AC,L,MD, LO	AC,L,MD,LO	AC,L,MD,LO	2	AC,L,MD,LO	AC,L,MD,LO	4	BOM
CONVERSION Electrical	Gaseous damage to plants	VU,L,MD, LO	AC,L,SV,SR	VL,L,SV,SR	1	VU,L,MD,LO	AI,S,I,LO	3	BOM
	Acid Rainfall	AC,L,MD, MC	AC,L,SV,N	AC,L,SV,N	1	AC,L,MD,MC	AI,S,I,LO	3	BOM
	Decreased soil productivity	VU,L,MD, LO	VL,L,MD,SR	P,L,SV,SR	1	VU,L,MD,LO	AI,S,I,LO	3	BOM
	Radioactive contamination	AI,L,MD, LO	AI,L,SV,LO	AI,L,SV,LO	2	AI,MD,MD,L	AI,L,SV,LO	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - BIOLOGICAL AND ECOLOGICAL IMPACTS - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION Both	Aquatic habitat destruction						
	1. Sedimentation	Recreation	SV,-	Protection of surface water	Require sediment traps & strips of vegetation; rapid revegetation; sedimentation ponds	State & Federal EPA, Bureau of Mines	
	2. Acid drainage	Recreation	SV,-	"	Deny discharge; rewater treatment	"	
PROCESSING	Gaseous damage to plants	Land Owners, Public	M/SV,-	Are standards adequate or enforced	Fines, shut downs New standards, Litigation	NRC	
CONVERSION Electrical	Gaseous damage to plants	Land Owners, Public	M/SV	"	"	EPA	
	Acid rainfall	Public, Public lands	M/SV,-	"	"	EPA	
	Decreased soil productivity	Farmers, Public lands	M/SV,-	"	"	EPA	
	Radioactive contamination	Land Owners	SV,-	"	"	NRC	
		Environmentalists	SV,-	"	Fines, shut downs New standards	NRC	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

D.10-16

3/3/77 bd

TABLE A - BIOLOGICAL AND ECOLOGICAL IMPACTS - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
CONVERSION (Con't) Electrical	Violation of Class 1, augmental air standards	VL,S, MD,R	AC,L,SV,R	AC,M,MD,R	1	VL,S,MD,R	VL,S,I,LO	3	BOM
	Threat to a significant site	AI,L, SV,LO	P,L,SV,LO	P,L,SV,LO	?	VU,L,SV,LO	VU,L,SV,LO	?	BOM
EXTRACTION Surface	Destruction of existing community	AC,M-L, SV,LO	AC,M-L,SV,LO	AC,M-L,SV,LO	1	AC,M-L,SV,LO	AC,M-L,SV,LO	3	BOM
	Loss of agricultural land	P,M-L, SV,LO	AC,M-L,SV,LO	VL,M-L,SV,LO	1	P,M-L,SV,LO	P,M-L,SV,LO	3	BOM
	Threat to a significant site	P,L,SV, LO	"	"	1	"	"	3	BOM
	Increased small game habitat and recreation areas	VU,L, SV,LO	P,L,SV,LO	P,L,SV,LO	1	VU,L,SV,LO	VU,L,SV,LO	3	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - BIOLOGICAL AND ECOLOGICAL IMPACTS - 4

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
CONVERSION (Con't) Electrical	Violation of Class 1	Recreation, environmentalists	M/SV,-	"	As above plus litigation	EPA	
	Threat to a significant site	"	SV,-	What is the value of these areas	Litigation, new laws	St.Dept. of Conservation, Historical gr groups	
EXTRACTION Surface	Destruction of existing community	Recreation	SV,-	How and will land be reclaimed?	Enforce existing laws, enact new laws, quality of reclaimed land 1. Agricultural 2. Recreation	State & Federal Bureau of Mines	
	Loss of agricultural land	Consumers	M,-	How and will land be reclaimed?	Return land to original use, improve productivity elsewhere	State & Federal Bureau of Mines	
		County Government	M,-	Loss of tax base and commerce	Return land to some use, zoning	"	
	Threat to a significant site	Environmentalists	SV,-	Protection of important site	Injunction	Courts	
	Increased small game habitat & recreation areas	Recreation	M,+	Best use of reclaimed land	Use of reclaimed land 1. Agricultural 2. Recreation	State & Federal Bureau of Mines	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - BIOLOGICAL AND ECOLOGICAL IMPACTS - 5

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION (Con't)									
Underground	Subsidence and alteration of surface drainage	AC,M, SV,MC	AC,L,SV,SR	AC,M,SV,SR	1	AC,M,SV,MC	AC,M,SV,MC	3	BOM
WASTE DISPOSAL									
Heat Cooling Towers Drift	Decreased productivity	VU,L,MD, LO	P,L,MD,SR	P,L,MD,SR	2	VU,L,MD,LO	VU,L,MD,LO	4	BOM
Blowdown water	Fish kills	VU,S,MD, LO	P,S,MD,MC	P,S,MD,MC	2	VU,S,MD,LO	VU,S,MD,LO	4	BOM
	Eutrophication	P,M,MD, LO	AC,M,SV,R	AC,M,SV,R	2	P,M,MD,LO	P,M,MD,LO	4	BOM
Reservoirs	Increased fishery and recreation area	AC,L,SV, SR	AC,L,SV,R	AC,L,SV,R	2	AC,L,SV,SR	AC,L,SV,SR	4	BOM
	Loss of present land use	AC,L,SV, L	AC,L,SV,LO	AC,L,SV,LO	2	AC,L,SV,LO	AC,L,SV,SR	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - BIOLOGICAL AND ECOLOGICAL IMPACTS - 6

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION (Con't)							
Underground	Subsidence and alteration of surface drainage	Land Owners	SV,-	Future land use	Replacement of drainage; litigation; tax with local government responsible for problem	State & Federal Bureau of Mines	
WASTE DISPOSAL							
Heat Cooling Towers Drift	Decreased productivity	Land Owners	M,-	Best method of heat disposal	Cooling towers or reservoirs	EPA, NRC	
Blowdown water	Fish kills	Recreation	M,-	"	"	" "	
	Eutrophication	"	M,-	"	"	" "	
Reservoirs	Increased fishery and recreation area	"	M,+	"	"	" "	
	Loss of present land use	Recreation, Land Owners	M,-	"	"	" "	

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

D.11 EMPLOYMENT IMPACTS

EMPLOYMENT

Direct employment patterns associated with new energy conversion facilities vary by type and size of the project (Figure 1).[1] During the planning and construction phase, the number of employees increases rapidly over a short period of time and then drops from the peak construction force to a relatively small, and stable, operating force. Of the type of conversion facilities projected for the ORBES region, coal gasification requires the largest number of construction employees over the shortest period of time. Coal-fired and nuclear-powered units have a similar construction schedule over a longer period of time. A nuclear-powered facility requires a larger peak-construction force, although it has the smallest number of operating employees.

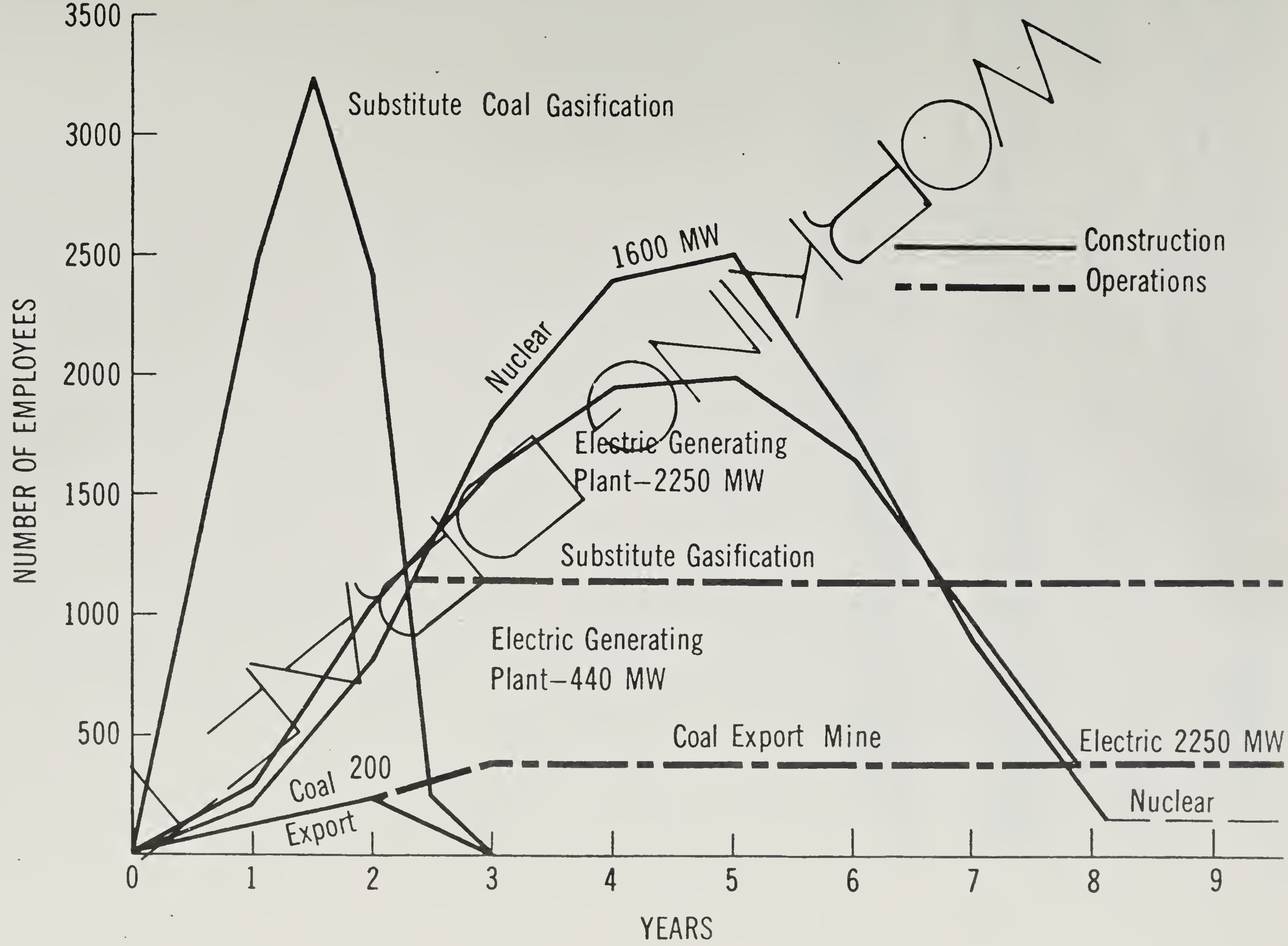
Direct employment opportunities will lead to a chain of impacts which include demographic change, and a host of other impacts in economic, social and institutional areas (cf. 1,2). Some of these are considered first-order impacts; others are interrelated second- and higher-order effects. These impacts, including other employment impacts, are considered in subsequent sections.

---

[1]Figure D.11-1 is from (1,p.4). The substitute coal gasification plant (250 million cubic feet per day) is proposed by El Paso Natural Gas Company and Western Gasification Company for the Navajo Reservation; the nuclear Calvert Cliffs, Maryland; the coal-fired plant is at Page, Arizona; and the coal export mine (9 million tons production per year) is at Fruitland, New Mexico. Other direct employment figures are in (4, pp. 12-35).

FIGURE D.11-1

EMPLOYMENT PATTERNS FOR SELECTED ENERGY PROJECTS



REFERENCES

1. Department of Housing and Urban Development. Rapid Growth from Energy Projects: Ideas for State and Local Action. Washington, D. C.: Department of Housing and Urban Development, Office of Community Planning and Development, 1976.

2. Gilmore, J. S., "Boom Towns May Hinder Energy Resources Development," Science, Vol. 191, February 13, 1976, pp. 535-540.

3. Stenejhem, E. J. and Baldwin, T. E. A Framework for Detailed Site-Specific Studies of Local Socioeconomic Impacts from Energy Development. Argonne, Illinois: Regional Studies Program, Argonne National Laboratory, December, 1976.

4. ______________. and Metzger, J. E. A Framework for Projecting Employment and Population Changes Accompanying Energy Development. Phase I. Argonne, Illinois: Regional Studies Program, Argonne National Laboratory, December, 1976.

D.12 DEMOGRAPHIC IMPACTS

INTRODUCTION

The first-order demographic impacts associated with new energy conversion facilities are changes in population size, migration patterns and selected structural characteristics of the population. Coal extraction, for example, may result in increased rates of population growth locally because of increased labor demand, and a subsequent increase in in-migration or reduced out-migration rates. No significant changes are expected in the birth rate, age structure or sex ratio of the resident population; death rates may increase.[1] The demographic impacts of underground mining are expected to be greater than the demographic impacts of surface mining because of different labor requirements.

Significant demographic impacts are also associated with conversion facilities.[2] The first impacts are from construction workers and their families who either move into the community as semi-permanent residents, or are long-term commuters. Construction employment, in turn, may create a demand for indirect as well as income-induced employment because of the expansion and diversification of the economic base (Fig. D.12-1)[3] As the number of construction workers declines and the population drops from the temporary peaks, the primary source of population changes during the operating phase of the facility changes to indirect employment opportunities. These indirect impacts, as well as those associated with end-use functions, are second- and higher-order impacts which, in the long term, may have the most significant cumulative impact upon the demographic characteristics of the ORBES region.

---

[1]Death rates are considered under Public Health impacts.

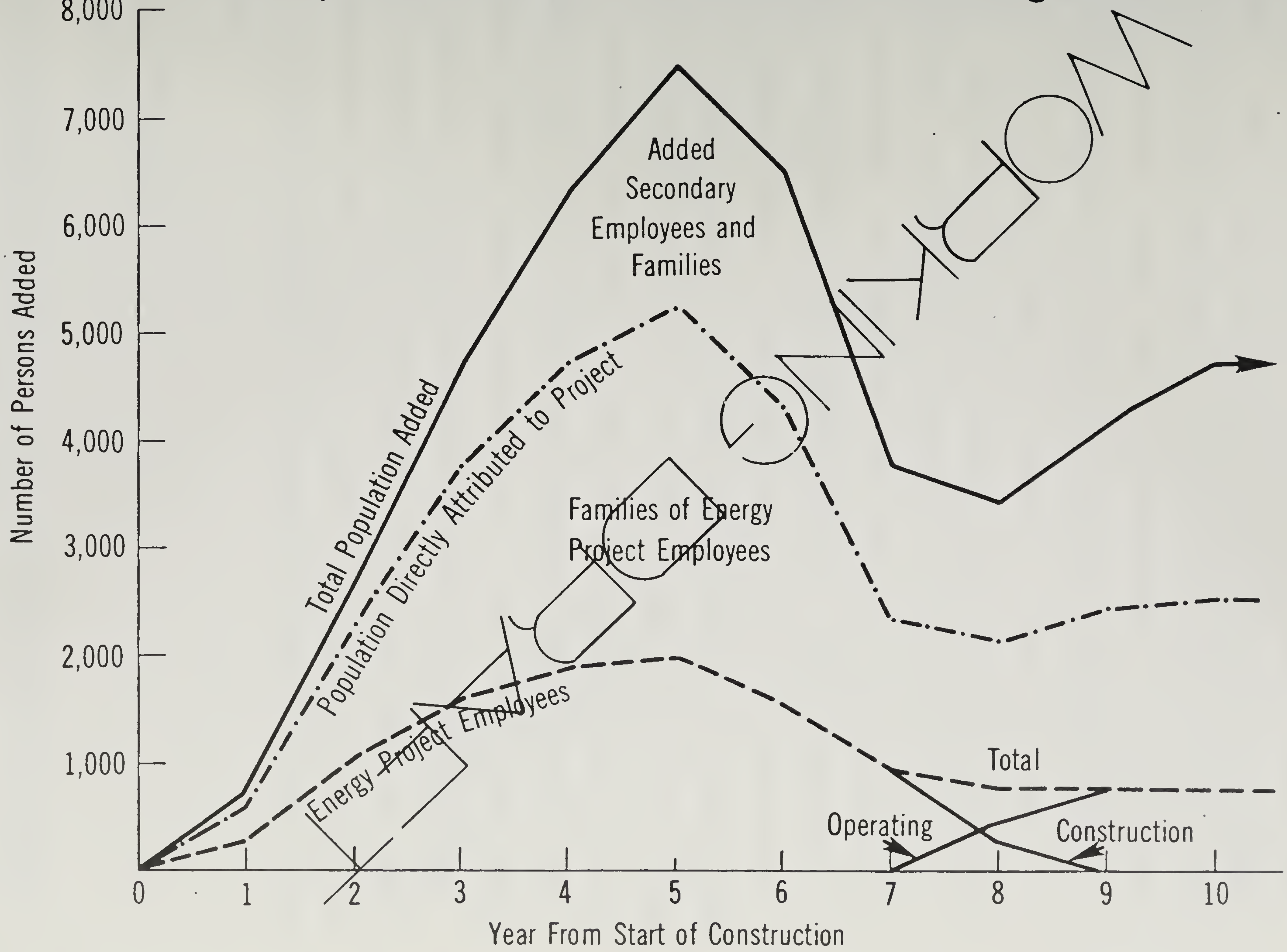
[2]This assumes that transportation and waste disposal are included in a general category of "operating functions."

[3] Figure D.12-1 is from (7, p.8).

FIGURE D.12-1

ADDED POPULATION FROM ENERGY PROJECT

Example of 2250 MW Coal-Fired Electric Generating Plant



The patterns of population change shown in Figure D.12-1 are generalized for places which follow a "boom town" cycle such as is common to energy development in the west (1,8,9,14,20,22). They will vary, however, according to the number, type and size of facilities and the socioeconomic environment of the region within which they are located. Five considerations are important (23, pp. 45-51). First, the more labor-intensive the technology, the more likely a community will experience significant demographic impacts. The impacts will differ between the construction and operating phases of a facility. Second, the impacts will be greater where the peak construction force is large, and the ratio of construction to operating employees is high. In this sense, coal gasification will have the greatest impact, followed by coal-fired and nuclear-powered facilities. Third, impacts will vary according to the time phasing and location of new plant construction. Dispersed siting is assumed for the ORBES region. However, if several sites (counties) are near, or adjacent to, one another, the impacts will be greater than if plants were more dispersed geographically. Fourth, impacts will vary by community size. Small, isolated rural communities usually provide very few services and facilities and have little or no planning for growth management. Fifth, the impacts vary according to the size, composition and geographical distribution of the labor force. A large local labor force which is diversified to meet the employment demands of new energy development will reduce the number of in-migrants or the distance from which they will migrate or commute.

Bureau of Mines Scenario

Extraction

Population growth in areas of coal extraction for the Bureau of Mines scenario is very likely to occur through the year 2000 as a result of a reduced out-migration and, in the long-term, increased in-migration. For this

reason, underground mines have a greater demographic impact than surface mines because they are more labor-intensive. Surface mines have less impact on population growth than upon the socioeconomic characteristics of the local population because of selective in-migration. Assumptions about the coal supply for the new facilities state that an increasing proportion will come from underground mines in the ORBES region (see Section D.3). Consequently, demographic impacts resulting from extraction are expected to increase toward the year 2000.

This study assumes that an adequate supply of nuclear fuel is available for import to the ORBES region. Demographic impacts may result in places where the extraction functions are located. However, this will have no significant demographic impact in the ORBES region.

Conversion

Population growth is almost certain to occur over the long term as a result of the conversion function. The amount of growth and its characteristics, however, will depend upon the particular fuel mix and the geographic distribution of facilities in each RTC. The majority of the plants located in contiguous blocs of counties (for example, in southwestern Indiana and Ohio, and along the Ohio River in southeastern Ohio) are in counties which have population growth rates since 1970 which are higher than state average and which are within or adjacent to Standard Metropolitan Statistical Areas (SMSAs). Most new facilities are located in counties which have existing (1975) or planned (1975-1985) facilities; and furthermore, most nuclear plants are located in counties which are also slected for new coal-fired facilities.

This pattern will have mixed demographic effects. In the long term, local population growth rates will accelerate as the result, first, of a

decrease in out-migration and then of an increase in in-migration. The accessibility of the new facilities to major metropolitan labor markets may dampen this trend somewhat and distribute it more equitably at multi-county scale if commuting patterns allow. The short-term impacts generally associated with construction may also be less significant locally for the same reason. However, the scale and pace of development under the BOM scenario are so great that the aggregate demographic effects will be significant at local, multi-county and perhaps even regional scale.

Relatively few counties have "boom town" site characteristics, analagous to those in the western United States. Counties that do are in southeastern Illinois and southwestern Indiana. They are still accessible to metropolitan labor markets which are projected sources for skilled construction workers (cf 2, pp. 4.57-59). Nevertheless, additional employment opportunities will reduce out-migration as well as increase in-migration of newcomers and return migrants (8,17).

Utilization

The demographic impacts which are associated with end-use functions are second- and higher-order effects. They are also largely unknown. Recent studies of industrialization in non-metropolitan areas, however, show that whereas the majority of new jobs are taken by local residents, newcomers and return migrants will compete successfully for those jobs requiring higher skill levels (8,17). The in-migrants may be the minority of the population growth in an area, but they will be significantly different from the people who remain as residents.

Comparison of 80-20 and 50-50 RTCs

The demographic impacts assoicated with the 80-20 fuel mix will be more severe than those associated with the 50-50 fuel mix. In general, the former is more labor-intensive in the conversion function and, because of assumptions about the coal supply, in extraction functions as well. Also, the geographical distribution of sites in the 80-20 RTC is more dispersed and includes more non-metropolitan counties.

The short-term impacts during construction may not differ significantly among the two RTCs, although the skill levels required for nuclear-powered plants suggest that in-migration may be more important in the 50-50 RTC. In the long term, the impact of in-migration during the operating phase of both RTCs may result in a younger age distribution for residents at the site. No significant changes in either the natural movement of the population (births and deaths) or sex ratio are expected. Perhaps the most significant characteristic of the BOM scenario is the great demand for labor which the number and time phasing of new plant construction requires.

A demographic impact which is common to both RTCs is the effect of energy development upon population change in counties which have no new energy conversion facilities. They may experience either reduced rates of in-migration or increased rates of out-migration as people move to areas with new economic opportunity. Assuming that migration to and from the ORBES region is insignificant, population redistribution at multi-county or subregional scale will contribute significantly to a shift of population growth to suburban and non-metropolitan areas where new energy development is located.

Comparison of BOM and Ford Technical Fix Scenarios

The scale and intensity of demographic impacts for the Ford Technical Fix scenario is more local and much less severe at regional scale than for the BOM scenario. The coal-based RTC has a greater long-term impact in terms of total population growth if only because of the extraction function and the slightly larger number of employees required to operate coal-fired facilities. The nulcear RTC will have the largest short-term impact because of the large number of peak-construction employees and, in the long term, because the selective in-migration of operating personnel will bring people of higher socioeconomic characteristics into local communities. However, the differences between the two Tech Fix RTCs are not significant end-use functions.

The demographic impacts of the Ford Technical Fix RTCs will be significant and severe at local scale. There is no reason to believe that they will have any significant impact upon population growth patterns beyond the counties which are adjacent to the sites, except in southeastern Ohio, where the sites are grouped along the Ohio River and adjacent to several SMSAs.

Issues, Problems and Parties at Interest

Building new energy conversion facilities in non-metropolitan areas may be considered as a potential source of local economic growth. Recent surveys show that local residents overwhelmingly support it as such, especially if the area has a high unemployment rate and the people are from lower socioeconomic groups (cf. 6). However, the same people offer significantly less support for population growth which may accompany either energy development or industrialization. This seeming paradox may reflect their parochialism, but it may also represent an apprehension toward, or intuititive understanding of, real problems which may result from the demographic impacts associated with new

[illegible]

[illegible]

[illegible]

[illegible]

energy development. A major problem in assessing energy development is the comparison of long-term benefits with the short-term impacts which may accompany rapid large-scale development.

Demographic impacts affect, directly or indirectly, a large number of parties at interest (Table D.12-1) at local scale —those concerned with population growth, and in-migration, in particular, including the real estate and housing industries; property owners; elected officials and planning agencies; and those who provide public goods and services. The list also includes labor unions, industry and merchants; special lobbies and interest groups; and state and federal agencies, many of whom are potentially responsive agencies as well. The list of parties at interest is the same for each function, although the severity of the impacts and their effects upon the parties at interest may vary.

Housing population growth is an immediate issue. It is least severe during extraction, especially surface mining; it is most severe during the construction of new conversion facilities, especially gasification and nuclear-powered plants, when large numbers of construction workers and then families move to the area on a semi-permanent basis. Long-term commuters need special quarters, but their impact is much less severe than that of semi-permanent in-migrants. Large mobile home parks ("aluminum ghettos") located beyond municipal boundaries are a frequent response to the housing crisis of construction workers (9).

The real estate and construction industry and financial institutions, as well as labor unions, merchants and agricultural landowners, are parties at interest in the housing issue. The impacts are favorable in each case. The new residents also bring demands upon those agencies providing public goods and services, as well as on elected officials and planning agencies. In general, the demand for police and fire protection, health and welfare ser-

vices may strain the capabilities of local groups. School systems also may become overcrowded, although those with declining enrollments may welcome an influx of new students provided they are supported by an increased tax base or other fiscal support. The severity of public sector impacts is mediated by fiscal variables (see Section D.13). Elected officials and planning groups are deeply involved if only because of tension and conflict over the demands placed upon them.

Agriculturalists, local residents and, indirectly, newcomers have an interest in changes in land use resulting from population growth. Agriculturalists have an interest because the majority of the land for new housing and other growth-related activities is likely to be farm land. The value of the land will increase in the long term, but so will taxes. Local residents may also profit in the short term but bear long-term tax increases because of increased property values. The newcomers, in turn, will likely face housing shortages and inflated costs, especially during the conversion phases if in-migration is large and there is no growth management policy. Environmentalists and conservation groups will also join the issue of changing land use, as population growth may be considered a direct cause of environmental degradation.[1] Land use planning is primarily the business of local government and planning agencies. Consequently, they have a direct interest in this impact of demographic change as well.

The increased demands upon public goods and services is a third major problem area. One aspect of the problem is fiscal, as explained below (Section D.13). Other aspects of the problem are more complex. For example, new housing developments may be located in unincorporated areas and thus face

---

[1]As is the case with many such groups, such an issue affects them favorably in the sense that it contributes to their importance and legitimacy.

police and fire groups with jurisdictional issues. Selective in-migration may add demands for specialized health care to the general increase in the demand for medical care. The courts may be faced with increased loads because of litigation arising from conflicts over land use and housing. On the other hand, the increased demand for public goods and services may have a positive effect upon local industry and business, and labor unions.

The employment of local people in energy development and other types of activities is an added problem. Most of the socioeconomic impact literature considers only the problems of newcomers (e.g., 1,9,19,20). However, employment opportunities which new energy conversion facilities bring to an area will also reduce the rate at which people leave in search of better jobs. Their occupational mobility will be limited, however, as newcomers and return migrants will claim many of the new jobs, especially those which require skills not generally available locally (10, 17). The problem is most severe during the conversion process, although it may continue through industrialization and other end-use functions. Labor unions and industry have special interests in such problems. Otherwise, the fact that local residents remain rather than migrate creates no particular impact upon other parties at interest except newcomers.

Two types of policies may address the issue of local employment. Affirmative action programs to hire and train local residents for jobs in new industry, including utility companies, is one approach. Another involves equal opportunity programs to increase local labor force participation across the board. In both cases, labor unions and employers are the potentially responsive agencies, with some assistance from the U.S. Department of Labor.

The policy options for other issues involve zoning and planning of some type, and include elected officials, zoning boards and planning commissions;

the courts; and a host of state and federal agencies as potentially responsive agencies.[1] Some communities may wish to limit population growth or rigidly control its characteristics through the housing market. Annual growth on the number and type of new housing units that can be built is one approach; exclusionary zoning is another.[2] Such policies have been used primarily by metropolitan suburbs in an attempt to "preserve the quality of life" and the "residential environment" of their community. Although they have the effect of excluding lower class socioeconomic groups, communities faced with large-scale population growth could also use such policies to limit access to their community of any group.

Planning for growth management is another policy option. One problem of exclusionary zoning is that other communities may be affected even more severely by population growth if people's residential choice is limited. Regional planning (at county or multi-county scale) for equitable population distribution and housing of all income groups is one solution to this problem. Although planning for growth management (which includes land use and zoning) has traditionally been considered a prerogative of municipal government, it is increasingly encouraged at all levels of local and state government through the interests of federal agencies such as the Department of Housing and Urban Development (7, 16) and lobbies such as the National Association of Counties (4). Local residents and their elected officials, however, may not welcome planning initiatives, especially when the federal government is involved (8,11). Regional planning does not have enthusiastic support, either.

Disputes over community growth policies frequently involve unlikely alliances between parties at interest. The real estate and construction industry,

---

[1] Only federal agencies are considered here.

[2] Limits on total population size is a more direct approach, but such actions are routinely declared unconstitutional.

financial institutions and other interests concerned with economic growth, and civil libertarians concerned over restrictions upon people's right to travel and choice of residence often oppose environmentalists and conservation groups concerned with environmental quality and land use, and elected officials and appointed commissions concerned with planning and growth management. The issues, which are focused primarily in metropolitan area suburbs, promise to spread into non-metropolitan areas which Wheaton (24, p. 26) refers to as "economic development areas where pipelines and well, shale oil, surface coal mining, dams, and other facilities —and in the future solar power stations— are required to serve a still growing population and to meet even more rapidly growing energy requirements." Wheaton argues that (24, p. 26):

> Probably in all of [these] cases there is no real competition between the need for housing space and the resources involved. In the aggregate, the space involved in these energy development areas is relatively small; usually in isolated areas and usually not involving pollution which spreads to urbanized areas. A far more difficult issue is the competition between resources, e.g., the water needs of shale oil distillation.

However, this ignores the attitudes of local residents toward the demographic impacts from population growth associated with new energy conversion facilities.

Summary

The severity of impacts and their effect upon the largest number of parties at interest will be greatest in the Bureau of Mines scenario for the 80-20 and then the 50-50 fuel mix. They will be less severe in the Technical Fix scenarios, both coal and nuclear, although the list of parties at interest remains the same. The BOM 80-20 fuel mix will also pose the widest range of problems because of the scale and pace of development, and the wide geographical range of new conversion facilities. Community growth policies, focused upon exclusionary zoning in metropolitan suburban areas as well as

[illegible]

[illegible]

> [illegible]

[illegible]

[illegible]

[illegible]

problems of growth management in non-metropolitan areas, may occur almost simultaneously. The scale of development may also raise significant issues of regional planning (perhaps even involving metro-government) because of the repercussions from demographic change in response to new energy development. By comparison, the Tech Fix scenario does not, with the exception of the Ohio plants in the nuclear-based RTC, have the same degree of geographical concentration. This is not to say that the problems and issues are less important, or that the impacts are less severe at local scale, but because they occur in fewer instances at local scale, the problems and issues may be more tractable.

REFERENCES

1. Baldwin, T. E. and Others. A Socioeconomic Assessment of Energy Development in a Small Rural County: Coal Gasification in Mercer County, North Dakota. 2 Vols.; Argonne, Illinois: Energy and Environmental Systems Division, Argonne National Laboratory, December, 1976.

2. Beck, R. W. and Associates. Environmental Analysis, Merom Generating Station. Prepared for Hoosier Energy Division of Indiana Statewide R.E.C., Inc. Denver: R. W. Beck and Associates, 1976.

3. Bjornstad, D. J. Fiscal Impacts Associated with Power Reactor Siting: A Paired Case Study. Oak Ridge, Tennessee: Oak Ridge National Laboratory, February, 1977.

4. Campbell, K. A. Preparing for Anticipated Growth. Greene County, Pennsylvania. NACo Case Studies on Energy Impacts, Number 3; Washington, D. C.: National Association of Counties, May, 1976.

5. Center for Energy Studies, University of Texas at Austin. Direct and Indirect Economic, Social and Environmental Impacts of the Passage of the California Nuclear Power Plant Initiative. 4 Vols.; Washington, D. C.: U.S. Government Printing Office, April, 1976.

6. Clemente, F. and Krannich, R., "Local Attitudes toward Industry and Growth," Rural Development, Vol. 2, No. 1, Fall, 1976.

7. Department of Housing and Urban Development. Rapid Growth from Energy Projects: Ideas for State and Local Action. Washington, D. C.: Department of Housing and Urban Development, Office of Community Planning and Development, 1976.

8. Gilmore, J. S., "Boom Towns May Hinder Energy Resource Development," Science, Vol. 191, February 13, 1976, pp. 535-540.

9. ____________ and Duff, M. K. Boom Town Growth Management. Boulder, Colorado: Westview, 1975.

10. Hansen, N. M. Intermediate-size Cities as Growth Centers: Applications for Kentucky, the Piedmont Crescent, the Ozarks and Texas. New York: Praeger, 1971.

11. Hudman, L. E. and Perich, W. E. "Attitudes and Perceptions of Rural Residents in Energy Growth Counties to Planning Needs and Planners," paper presented to the American Institute of Planners, Annual Meeting, San Antonio, Texas, 1975.

12. Johnson, S. and Randall, A. "Social, Political and Institutional Aspects of Coal Utilization," paper presented to the Water for Energy Development Conference, Engineering Foundation and U.S. Water Resources Council, Pacific Grove, California, December 5-10, 1976.

REFERENCES (CONTINUED)

13. A Legal Study Relating to Coal Development —Population Issues. Vol. 1: Responding to Rapid Population Growth. Prepared for the Old West Regional Commission by Kutak, Rock, Cohen, Campbell, Garfinkle and Woodward, Omaha, Nebraska. Washington, D. C.: Old West Regional Commission, 1974.

14. Leholm, A., Leistritz, F. L. and Hertsgaard, T. Local Impacts of Energy Resource Development in the Northern Great Plains. Fargo, North Dakota: Northern Great Plains Resources Program, September, 1974.

15. Lopreato, S. C. and Leflow, K. "Local Impacts of Drilling, Development and Production." In Proceedings of the Second Geopressured Geothermal Energy Conference. Vol. V: Legal, Institutional and Environmental. Austin: Center for Energy Studies, University of Texas at Austin, 1976.

16. Mountain Plains Federal Regional Council, Socioeconomic Impacts of Natural Resource Development Committee. Socioeconomic Impacts and Federal Assistance in Energy Development Impacted Communities in Region VIII. Denver: Mountain Plains Federal Regional Council, 1975.

17. Olsen, D. A. and Kuenk, J. A. Migrant Response to Industrialization in Four Rural Areas, 1965-1970. Agricultural Economic Report No. 270; Columbia, Missouri: Agricultural Experiment Station, Missouri University, September, 1974.

18. Purdy, B. J. and Others. Post Licensing Case Study of Community Effects at Two Operating Nuclear Power Plants. Final Report, March 1975 - March 1976. Oak Ridge, Tennessee: Oak Ridge National Laboratory, June, 1976.

19. Stenejhem, E. J. Forecasting the Local Impacts of Energy Resource Development. ANL/AA-3, Environmental Control Technology and Earth Sciences (UC-11); Argonne, Illinois: Argonne National Laboratory, December, 1975.

20. ________________ and Baldwin, T. E. A Framework for Detailed Site-Specific Studies of Local Socioeconomic Impacts from Energy Development. Argonne, Illinois: Regional Studies Program, Argonne National Laboratory, December, 1976.

21. Traub, R. M. The Socioeconomic Impact of Nuclear Power Plants on Small Communities. Columbus, Ohio: Ohio Power Siting Commission, 1975.

22. University of Denver Research Institute. The Socioeconomic, and Land Use Impacts of a Fort Union Coal Processing Complex. Washington, D. C.: ERDA-Fossil Fuels, FE-1526-T-1, May, 1975.

23. White, J. L. (Jack) and Others. Draft: First Year Progress Report of a Technology Assessment of Western Energy Resource Development. Vol 1: Summary. Washington, D. C.: Office of Research and Development, U.S. Environmental Protection Agency.

24. Wheaton, W. L. C. "Conservation and Exclusion." The Center Magazine, January/February, 1976, pp. 23-27.

D.12-1

TABLE A - DEMOGRAPHIC IMPACTS - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION									
	Population growth	VL,M,I, LO	VL,M,MD, LO-MC	VL,M,MD-I, LO-MC	1	VL,M,MD-I, LO		3	BC'
	Increase in-migration	P,S,I, LO	P,S,MD,LO-MC	P,S,I,LO-MC	1	P,S,I,LO-MC		3	BOM
	Reduce out-migration	P,S,I, LO	P,S,MD,LO-MC	P,S,I,LO-MC	1	P,S,I,LO-MC		3	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - DEMOGRAPHIC IMPACTS - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION	Population growth	Real estate ind. Construction Financial inst.	M-I, +	Housing	Exclusionary & inclusionary zoning	Zoning boards & Planning Commissions	
	Increase in-migration	Agriculturalists Local residents Newcomers	M-I, + M-I, - M-I, o	Land use	Restrictions on no.& type of new housing units	Local government	
No significant differences between surface and underground mining of coal.		Environmentalists & conversion groups	M-I, -	Local, regional & state planning	Comm. Dev. Block Grants (HUD)	HUD, EPA, FEA	
						Coastal zone management	
		Civil libertarians	M-I, -		701 Planning Grants (HUD)		
		Elected local officials Planning agen.	M, +,- M, +,-		Regional planning for equitable population distribution & housing of all income groups	Economic Development Adm. FHA, LEAA, HEW (Health maintenance organizations)	
		Public utilities School systems	M-I, - M-I, +,-			Regional Planning Comm.	
	Reduce out-migration	Health & welfare services	M-I, -	Provision of public goods & services	Affirmative Action Programs to hire & train local residents		
		Courts & law enforcement officials	M-I, -		Equal opportunity programs to increase labor force participation		
		Labor unions Industry Merchants	M-I, + M-I, +,- M-I, +				

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

EPA	M-I, +, -	National Assoc. of Counties, etc.	M-I, +
ERDA	M-I, +, -	Economic Development Admin.	M-I, +
HUD	M-I, +	Department of Agriculture	-

3/3/77 bd

TABLE A - DEMOGRAPHIC IMPACTS - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
CONVERSION									
	Population growth	VL,M,I, LO	AC,L,MD,LO-MC	AC,L,MD-I, LO-MC	1	VL,M,MD-I,LO	VL,MD,MD-I,LO	3	BOM
	Increase in-migration	P,M,I, LO-MC	AC,M,MD,LO-MC	AC,S-M,MD,LO-R	1	AC-VL,M,MD, LO-MC	AC,M,MD,LO-R	4	BOM
	Younger age structure	VU,L,I, LO	P,L,MD,LO	P,L,I,LO	1	VU,L,I,LO	P,L,I,LO	4	BOM
	Reduce out-migration	P,M,I, LO-MC	VL,M,MD,LO-MC	P,M,MD-I,LO-MC	1	VL-P,M,MD-I, LO-MC	VU,L,I,LO	3	BOM

D.12-18

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - DEMOGRAPHIC IMPACTS - 4

Function	Impact	Parties at Interest	Character-ization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
CONVERSION	Population growth	Real estate ind. Construction Financial inst.	M, + M, + M-S, +,-	Housing	Exclusionary & inclusionary zoning	Zoning boards & Planning Commissions	
	Increase in-migration	Agriculturalists Local residents Newcomers	M, + M-S, - M-S, -	Land use	Restrictions on no.& type of new housing units	Local government HUD, EPA, FEA	
		Environmental-ists & conserva-tion groups	M, -	Local, regional and state planning	Comm. Dev. Block Grants (HUD)	Coastal zone management	
		Civil liber-tarians	M, -		Regional plan-ning for equit-able population distribution & housing of all income groups	Economic De-velopment Adm FHA, LEAA, HEW (Health maintenance organizations)	
		Elected local officials Planning agen.	M-S, M-S, -,+				
	Younger age structure	Public utilities School systems	M-S, - M-S, -,+		Affirmative Action Programs to hire & train local residents	Regional Planning Com.	
	Reduce out-migration	Health & welfare services	M-S, -	Provision of public goods & services	Equal opportuni-ty programs to increase labor force participa-tion		
		Courts & law en-forcement offi-cials	M-S, -				
		Labor unions Industry Merchants	M, + M-S, +,- M, +				

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

EPA	M, +,-	National Assoc. of Counties, etc.	M, +
ERDA	M, +,-	Economic Development Adm.	M, +
HUD	M, +	Department of Agriculture	M, +

3/3/77 bd

TABLE A - DEMOGRAPHIC IMPACTS - 5

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
UTILIZATION									
	Population growth	VL,M,I, LO	AC,L,MD,LO-MC	AC,L,MD-I, LO-MC	1	VL,M,MD-I,LO	VL,MD,MD-I,LO	3	BOM
	Increase in-migration	P,M,I, LO-MC	AC,M,MD,LO-MC	AC,S-M,MD,LO-R	1	AC-VL,M,MD, LO-MC	AC,M,MD,LO-MC	4	BOM
	Younger age structure	VU,L,I, LO	P,L,MD,LO	P,L,I,LO	1	VU,L,I,LO	P,L,I,LO	4	BOM
	Reduce out-migration	P,M,I, LO-MC	VL,M,MD,LO-MC	P,M,MD-I,LO-MC	1	VL-P,M,MD-I, LO-MC	VU,L,I,LO	3	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - DEMOGRAPHIC IMPACTS - 6

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
UTILIZATION	Population growth	Real estate ind. Construction Financial inst.	M, + M, + M-S, +,-	Housing	Exclusionary & inclusionary zoning	Zoning boards & Planning Commissions	
	Increase in-migration	Agriculturalists Local residents Newcomers	M, + M, - M, -	Land use	Restrictions on no.& type of new housing units	Local government	
		Environmentalists & conservation groups	M-S, -	Local, regional & state planning	Comm. Dev. Block Grants (HUD)	HUD,EPA,FEA	
						Coastal zone management	
		Civil libertarians	M-S, -		701 Planning Grants (HUD)		
		Elected officials Planning agen.	M-S, - M-S, -,+		Regional planning for equitable population distribution & housing of all income groups	Economic Development Adm. FHA, LEAA, HEW (Health maintenance organizations)	
	Younger age structure	Public utilities School systems	M-S, - M, -			Regional Planning Comm.	
		Health & welfare services	M, -		Affirmative Action Programs to hire & train local residents		
	Reduce out-migration	Courts & law enforcement officials	M, -	Provision of public goods & services	Equal opportunity programs to increase labor force participation		
		Labor unions Industry Merchants	M, + M, +,- M, +				

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

EPA	M, +,-	National Assoc. of Counties, etc.	M, +
ERDA	M, +,-	Economic Development Adm.	M, +
HUD	M, +	Department of Agriculture	M, +

3/3/77 bd

D.13 ECONOMIC IMPACTS

The Regional Technology Configurations developed as plausible responses to the BOM and Tech Fix scenarios may produce economic impacts on a local, regional, or national scale. A discussion of economic impacts at these levels is presented below. Other significant economic impacts are identified for further study.

National Economic Impacts

Because the BOM and Tech Fix national projections were adopted as scenarios for the ORBES Phase I study, it is not meaningful to discuss the impacts of these scenarios, or of derivative RTCs, on themselves. Interesting and crucial questions arise, however, concerning the internal consistency, realizability, and probability of occurence of the national scenarios. One possible product of the ORBES study may be the demonstration that existing constraints prevent a scenario from materializing. Exploration of national projections for the purpose of testing feedback loops and adjustment mechanisms, and for painting a detailed picture of the economy as it grows, usually requires an elaborate macroeconomic computer model. Such an investigation is beyond the scope of the present study, but some rough observations can be made.

Since the BOM projections were not based on an actual model of the U.S. economy, many significant variables were not considered in the projections. The issues of capital availability, interest rates, savings rates, and capital/labor ratios, as examples, were bypassed completely. When no specific assumptions are made regarding these variables, it is not possible to discuss implications of the assumptions; but by drawing on other more complete models of the U.S. economy with energy included, it is possible to lend some legitimacy to the BOM projections. The Data Resources Inc. (DRI) macroeconomic models have been

exercised under growth rates approximating those in the BOM projections, with no catastrophic effects. Moreover, DRI employs an equilibrium model in which savings equal investment, including the projected high levels of energy industry investment. This suggests that under "reasonable" assumptions, the capital requirements of the electric utilities will be met under the BOM scenario; it also serves to corroborate the ORBES technological assumption that "capital will be available." It should be stressed, however, that all of the implications of this assumption cannot be determined. Planned investment is rarely equal to actual investment and there is reason to expect spirited competition in the future for investment funds in the capital markets. To the extent that interest rates rise, income may be redistributed in favor of rentiers. About all that can be said for sure is that investors best able to pay for investment funds will have first choice, and the U.S. Government will be able to obtain its funds through deficits if necessary. Given the absence of detail in any of the macroeconomic models and the significant structural changes in the economy expected to result from energy developments, relatively little information is available on the detailed appearance of the U.S. economy under the BOM scenario.

Since the Tech Fix projections are less severe than those of the Bureau of Mines, there is justification for greater confidence in their realizability. Also, the Tech Fix projections were based on a formal macroeconomic model and greater detail on the implications of the Tech Fix assumptions is presented in the Ford Foundation Report.

The identification, and in many cases, quantification of impacts associated with RTCs in Phase I, should provide a unique and productive input to detailed examination of ORBES scenarios and their implications during Phase II.

Regional Economic Impacts

All of the technical difficulties discussed above, in connection with national economic impacts, apply as well to the regional level. The assessment of regional economic impacts poses further problems because certain variables, such as national business investment, cannot be allocated to specific regions of the country. For the ORBES study, it would be useful to know whether, and how, the ORBES economy differs from the U.S. economy and how its future growth path diverges from its historical growth pattern under various scenarios and associated RTCs. In particular, the behavior of variables such as per capita income, output mix of goods and services, and employment are of interest. The production of this information requires the simultaneous development of both regional and national projections with explicit interactive regional/national linkages. Such a task involves a substantial research effort, however, and the possibility of adapting the 1972-E OBERS projections (Baseline Futures) to ORBES requirements is under investigation. A description of the OBERS data and its applicability to ORBES requirements will be presented in future reports of the current Task 2 study.

been necessary during Phase I to adopt a fixed historical shares assumption for the ORBES region. That is, the ORBES future shares of national energy production and consumption are assumed constant and equal to historical shares. This assumption forecloses the possibility of identifying any future divergences of the ORBES region from its historical trends or from its historical relationship to the nation. During Phase II, with the development of appropriate regional/national projections, this assumption will be relaxed and the critical issues identified above will be investigated.

Local Economic Impacts

The nature and magnitude of economic impacts associated with siting in a specific locality can be examined more readily than those associated with a particular RTC. In cases where specific sites have been identified, and where construction is scheduled to begin within 3 or 4 years, it is possible, though costly, to generate useful quantitative estimates of local economic impacts. As planning horizons lengthen, however, projections become less reliable. For the ORBES study, it is desirable to assess local economic impacts which may occur as late as the year 2000, for plausible sites identified only at the county level. This goal raises special technical problems not treated in the socioeconomic assessment literature, most of which is concerned with specific sites and much shorter horizons. The major problem areas are discussed below.

1. Identification of a plausible site at the county level does not mean that economic impacts will be confined to that county. Impacts may be more significant in adjacent counties or even adjacent states. The spatial distribution of economic impacts is highly sensitive to the actual site within the identified county.

2. Reliable and comprehensive baseline projections to the year 2000 are not currently available. Such projections are essential to the identification and quantification of economic impacts at the municipal and county levels. The inherently volatile and site-specific nature of small town development undermines confidence in the extrapolation forward of historical trends. But even if useful projections were available, they would be required for every feasible siting location within the identified counties.

In view of these problems, it does not appear possible to attribute any certain economic impacts to the identified counties other than the following:

1. The county of siting will experience an eventual increase in its capacity to raise tax revenues.

2. The county of siting will experience a net increase in employment.

Potential local economic impacts are discussed below in general terms, and grouped according to whether they are likely to occur during the planning, construction, or operating phases.

Planning Phase

During and immediately following the period of utility negotiations for the purchase of land, some degree of land speculation may take place. Depending upon landowners' expectations of future land values, land prices could rise significantly, with some impact on rents and future economic development. Similarly, in anticipation of future shortages, housing rents and prices may begin to rise. The magnitude of such effects is likely to be greatest in and around the communities nearest the planned site, decreasing with distance from it. Impacts may be minimal near those sites which have long been earmarked for industrial development.

Construction Phase

Local economic impacts associated with the construction of the facility will exhibit considerable sensitivity to site-specific conditions. As described in the Employment section of this study, two to three thousand construction workers may be employed on site at the peak of this activity. The extent of the economic impact will depend directly upon what portion of this labor force is made up of local residents, temporary residents during the construction phase, and commuters from outlying communities.

It is possible that most or all of this labor force will be made up of

commuters for some of the selected counties. For others, however, the majority of construction workers may take up temporary residence in communities near the site. Direct economic impacts will be greater in the latter case and will include the following:

1. Increased direct local employment (construction)
2. Increased demands for local private sector goods and services, including housing.
3. Increased demands for public sector services, including schools, roads, police, fire, waste disposal.

To the extent that private sector demand increases faster than supply, temporary shortages, price rises and inefficiencies brought about by rapid change may occur. There may be local reluctance to adapt completely to the massive influx of workers since their presense in the community is known to be temporary. If so, the mix of goods and services available locally may be incomplete, requiring considerable additional travel for some items.

In order to meet the increased, though temporary, demand for private sector goods and services, there may be increased employment in this sector. The magnitude of such an increase will depend on the number of construction workers taking up residence in the local communities (i.e., non-commuters). As construction nears completion, direct employment will taper off significantly, requiring some readjustment of the business community toward pre-construction levels.

The most potentially significant local economic impacts may occur in the public sector. To the extent that the construction labor force demands additional or different public services such as schooling, waste disposal, water, police and fire protection, an increased strain may be placed on local governmental units. Again, the severity of impact will depend in

part on the number of construction workers who take up residence in the local communities. Problems may arise in the following ways.

1. Increased demand for public services is known to be temporary. Construction of schools, for example, would be costly when used only for a few years.

2. Depending upon site-specific scale economies and existing excess capacity, maintenance of pre-construction public service levels could be more costly for all local residents.

3. Tax revenues to finance increased provision of public services may lag the increased demands by a considerable period.

Operating Phase

The operating phase of the facility siting process is characterized by the continuous employment of approximately 200 individuals for the lifetime of the facility. Economic impacts deriving from direct employment will be similar to those described for the construction phase with two important exceptions.

1. Most or all of the operating personnel can be expected to reside in the local communities, rather than commute.

2. Direct employment will be relatively permanent.

Following the above, indirect employment in both private and public sectors may increase through expansion of these sectors in response to the demands of operating personnel for additional or different goods and services. The magnitude of impacts during this phase depends, as before, on existing excess capacity and scale economies, but also on the extent to which increased demands were accommodated during the construction phase. If the construction phase was a period of local economic expansion, then the early operating phase may be marked by economic contraction.

Much of the socioeconomic impact assessment literature has dealt with the problem of estimating "employment multipliers" for prediction of indirect local employment during the operating phase. A preliminary review of that literature suggests the multiplier concept may be inappropriate to ORBES requirements. First, the theory upon which the multiplier derivations are based requires that conversion facility employment be assumed identical to existing regional "export industry" employment in terms of secondary/indirect employment generated. This assumption lacks intuitive appeal and has not been verified. It may be argued that regional export industries often rely upon the local economy for the supply of goods and services to a far greater degree than would a conversion facility. If so, the usual employment multiplier may significantly overstate the secondary employment impact. Second, most of the employment multipliers estimated in the impact assessment literature are derived from county level data, whereas local economic impacts, as stated earlier, may be greater in adjacent counties or states. Third, employment multipliers estimated on the basis of historical data cannot be expected to maintain any relevance over the ORBES 1985-2000 horizon.

Other Economic Impacts

In addition to national, regional, and local impacts, as discussed above, there are certain to be other economic impacts associated with the RTCs. Included are economic analysis of:

1. environmental and land use impacts.
2. transportation (especially railroad) impacts.
3. mining and materials resources impacts.
4. inter-regional impacts.

Some of the economic impacts are expected to be highly significant and thus warrant detailed examination. In general, however, analysis requires at least some quantification of the impacts, which will not be available until the end of Phase I. Therefore, treatment of these impacts will be appropriately undertaken during the ORBES Phase II study.

REFERENCES

1. Baldwin, T. E. and Others. A Socioeconomic Assessment of Energy Development in a Small Rural County: Coal Gasification in Mercer County, North Dakota. 2 Vols.; Argonne, Illinois: Energy and Environmental Systems Division, Argonne National Laboratory, December, 1976.

2. Department of Housing and Urban Development. Rapid Growth from Energy Projects: Ideas for State and Local Action. Washington, D. C.: Department of Housing and Urban Development, Office of Community Development, 1976.

3. Bjornstad, D. J. Fiscal Impacts Associated with Power Reactor Siting: A Paired Case Study. Oak Ridge, Tennessee: Oak Ridge National Laboratory, February, 1977.

4. Stenejhem, E. J. Forecasting the Local Impacts of Energy Resource Development. ANL/AA-3, Environmental Control Technology and Earth Sciences (UC-11); Argonne, Illinois: Argonne National Laboratory, December, 1975.

5. ________________ and Baldwin, T. E. A Framework for Detailed Site-Specific Studies of Local Socioeconomic Impacts from Energy Development. Argonne, Illinois: Regional Studies Program, Argonne National Laboratory, December, 1976.

6. Resource Planning Associates. Energy Supply/Demand Alternatives for the Appalachian Region, Prepared for National Science Foundation and Council on Environmental Quality, March, 1975.

D.13-1

TABLE A - LOCAL ECONOMIC IMPACTS - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) ~~2000 Tech~~ Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
PLANNING PHASE (Coal and Nuclear)	Speculation; rising land, housing, rental prices.	Possible	Possible	Possible	--	Possible	Possible	--	--
CONSTRUCTION PHASE (Coal and Nuclear)	Increase in local employment	AC,L, MO	AC,M,LO	AC,M,LO	--	AC,M,LO	AC,M,LO	--	--
	Incr. demand for public/private goods & services	AC,M, MC	AC,M,MC	AC,M,MC	--	AC,M,MC	AC,M,MC	--	--
	Shortages	M Possible,MC	M,Possible MC	M,Possible, MC	--	M,Possible MC	M,Possible, MC	--	--
OPERATING PHASE (Coal and Nuclear)	Increase in local employment	AC,L,LO	AC,L,LO	AC,L,LO	--	AC,L,LO	AC,L,LO	--	--
	Incr. capacity to raise tax revenues	AC,L,LO	AC,L,LO	AC,L,LO	--	AC,L,LO	AC,L,LO	--	--
	Incr. demand for public/private goods & services	AC,L,MC	AC,L,MC	AC,L,MC	--	AC,L,MC	AC,L,MC	--	--

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - LOCAL ECONOMIC IMPACTS - 2

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
PLANNING PHASE (Coal and Nuclear)	Speculation; rising land, housing, prices	Participants in real estate and related markets, county; municipal taxing authorities	(See legend below) ?	--	--		
CONSTRUCTION PHASE (Coal and Nuclear)	Temp. incr. in local employment; incr. demands for public/ private goods & services; shortages.	Local, regional, nat'l labor pool; local governments; local residents; local merchants.	?	Tax revenues lag demands for public services	Planning; state, federal assistance in providing public services		
OPERATING PHASE (Coal and Nuclear)	Permanent incr. in local employment; incr. capacity to raise tax revenues; incr. demand for public/ private goods and services (over pre-planning levels).	Same as for construction phase.	?	--	As above		

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

D.14 SOCIAL IMPACTS

Developing technologies and their resulting proliferation impact the quality of life and the sociocultural elements of society. The parameters of interest in a study of the impacts of technology will vary from researcher to researcher; little consensus has been achieved. The "shopping lists" of impacts and related factors increase in length, but within the frame of reference dictated by general work group decisions, this phase of the ORBES project has been concerned with the following:

1. Identifying characteristics of the population that may be affected by power generating facilities, such as population age distribution, population movements, community stability, etc.

2. Identifying socioeconomic characteristics that may be affected, such as standards of living, employment-unemployment, public welfare, etc.

3. Identifying socioinstitutional characteristics of the population that may be affected, such as public service facilities, education, public health facilities, religious institutions, etc.

4. Identifying sociopolitical characteristics that may be affected, such as community leadership patterns, power (political) centers shifting, liberal-conservative changes, etc.

These impacts are considered simultaneously on several dimensions: the likelihood, severity, longevity, and geographical scope. In addition, two fuel sources are considered (coal and nuclear) over two time periods: 1985, and 2000 (80% coal - 20% nuclear RTC), 2000 (50% coal - 50% nuclear RTC), 2000 (100% coal RTC), 2000 (100% nuclear RTC). In the discussion of impacts, some impacts associated with nuclear energy will be more or less pronounced, depending on which RTC is chosen, i.e., the dangers of radiation to public health in general and workers' health in particular, the danger of nuclear disasters, etc. However, it should be pointed out that many of the impacts of coal- or nuclear-related energy functions will be similar along those four dimensions, particularly concerning the excavation and transportation

[illegible]

of materials.

For example, consideration of the societal impacts of the two Tech Fix RTCs (100% coal or 100% nuclear) reveals more similarities than differences. Many of the technical functions associated with either coal or nuclear generation of electricity have similar societal impacts. Each of these fucntions is discussed below.

The extraction of coal or uranium affects the aesthetics of the landscape and the uses to which the land can be put after extraction has ceased. Surface mining results in dispoilation that dimishes the usefulness of the land for outdoor recreation unless reclamation and restoration efforts are taken. Underground mining affects a more limited portion of the surface land, but presents the problem of subsidence which may cause damage to farmland and waterways (erosion would increase the silt load in water). Agricultural parties at interest are obviously affected, but recreational users of waterways will also be affected. As new mining centers are developed, population movements into these producing regions will occur and concerns about worker safety and health will become important.

The processing functions of milling, cleaning, and, for nuclear materials, enriching and fabricating, constitute a major pollution impact on both air and water quality. The obvious societal impacts of air and water pollution revolve around the quality of life issue. People demand clean air and water as an inherent quality of their existence. When these are affected, outdoor aesthetics as well as the many forms of outdoor recreation are negatively impacted.

Transportation has several societal impacts that are secondary in nature to what is being transported. Vehicular traffic pollutes the air and causes great "wear and tear" on the roads of a region. The expenses associated with road repair and maintenance can put a considerable burden

on taxpayers. The inhabitants of the region must also use the damaged roads and drive among an increased number of heavy trucks.

Waste disposal is similar to processing in that it involves both water and air pollution, but in addition there is solid waste that must be disposed of by putting it back on or back into the land. The resulting dispoilation reduces the aesthetic quality of the landscape as well as the uses of the land for outdoor recreation. If solid wastes are disposed of near or into waterways, the impact of water pollution on the residents of the region would be increased.

Since many social impacts affect the quality of life by altering air, water, and land-use quality, the parties at interest are expected to be those with specific interests related to these impacts. Economic groups such as landowners, realtors, and farmers will be affected, as energy production affects the potential uses and therefore the potential value of their land and livelihood. Specific organizations such as the local Chambers of Commerce, the Grange, and service groups like the Rotary or Kiwanis may act as spokesmen for these individuals and as centers of action to affect policy. Environmental and recreational groups will also serve in a similar manner to mobilize public concern for impacted parties at interest such as Rod and Gun Clubs, the National Wildlife Federation, Audubon groups, and the Sierra Club. Different parties at interest are involved when discussing the impacts of nuclear generating facilities than when discussing those of coal-fired facilities. An obvious group of interested parties includes those governmental agencies that regulate the transportation, utilization, and storage of nuclear materials. The U.S. Nuclear Regulatory Commission is the primary Federal agency; state agencies, however, are often difficult to identify because they are often subcomponents of larger agencies. There are also several citizens' organizations that generally express opinions and

have programs designed to stop, slow down, or reduce the development of nuclear generating facilities. These groups differ greatly in their levels of organization, leadership, resources, and political effectiveness, but they must certainly be considered as parties at interest.

The differences between the two Tech Fix RTCs are due mainly to the radioactive nature of the nuclear materials transported and used and the accompanying community and worker health problems. There is also considerable social concern over the possibility of a nuclear disaster at a nuclear generating facility and the attendant need for increased security at such facilities as well as during transport of nuclear material.

COMPARISON OF TECH FIX WITH BOM

Because of the many similarities and the few, though obvious, differences, it is difficult to say whether the 100% coal or the 100% nuclear RTC will be more severe in terms of social impacts. It is probable, though, that either will be less severe than either of the BOM RTCs because the Tech Fix RTCs are based on considerably less development and growth between now and the year 2000.

D.14-1
TABLE A - SOCIAL IMPACTS - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION Surface	Increased employment.	VL,M, MD,N	VL,L,SV,N	VL,M,MD,N	1	**			
	Dispoilation of land (outdoor aesthetics & recreation affected greatly).	VL,M, S,N	VL,M,MD,N	VL,M,MD,N	1				
	Movement of population into producing regions--leads to increased demand on public facilities.		VL,L,M,R	VL,M,MD,R	1				
Underground	Increased employment.	VL,M, MD,N	VL,L,SV,N	VL,L,MD,N	1				
	Safety & health of workers.	AC,M, SV,N	AC,L,SV,N	AC,L,SV,N	1				
	Movement of population into producing regions.		AC,L,SV,R	AC,M,MD,R	1				

**The impacts of the Ford Tech Fix Scenario and the comparisons between BOM & Tech Fix RTCs are outlined in the preceeding narrative.

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

TABLE A - SOCIAL IMPACTS - 2

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
PROCESSING Coal-Related	Air & water pollution affecting quality of life & outdoor recreation.	VL,M, MD,LO	VL,M,SV,LO	VL,M,MD,LO	1	**			
Nuclear Related	Health hazards due to radioactivity for employees.	VL,M, MD,LO	VL,L,MD,LO	VL,L,SV,LO	1				
CONVERSION Electrical Generation	Air pollution affecting quality of life.	AC,M, SV, LO-MC	VL,L,MD,LO-MC	VL,L,MD,LO-MC	1				
	Greater employment in expanding electrical energy flow.	P,M, MD,N	VL,L,MD,N	VL,L,MD,N	1				
	Less reliance on oil.	P,S, MD,N	VL,L,MD,N	VL,L,MD,N	1				
TRANSPORTATION Train	Increasing employment.	P,M, MD,N	VL,L,MD,N	VL,L,MD,N	1				
Truck	Vehicular pollution.	VL,M, SV,LO	VL,L,SV,LO	VL,L,MD,LO	1				
Barge	Water recreation adversely affected.	P,M, MD,R	VL,L,SV,R	VL,L,MD,R	1				

**The impacts of the Ford Tech Fix Scenario and the comparisons between BOM & Tech Fix RTCs are outlined in the preceeding narrative.

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

TABLE A - SOCIAL IMPACTS - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
WASTE DISPOSAL									
Scrubber Sludge	Dispoilation of land affecting aesthetics and recreation.	VL,M, SV,LO	VL,L,SV,LO	VL,L,MD,LO	1	**			
Water	Water recreation adversely affected.	VL,M, SV,R	VL,L,SV,SR	VL,L,MD,SR	1				
Ash	Dispoilation of land affecting aesthetics and recreation.	VL,M, SV,LO	VL,L,SV,LO	VL,L,MD,LO	1				
Permanent storage	Nothing is permanent!				2				

**The impacts of the Ford Tech Fix Scenario and the comparisons between BOM & Tech Fix RTCs are outlined in the preceeding narrative.

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

TABLE A - SOCIAL IMPACTS - 4

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
UTILIZATION Electrical Generation	Less reliance on oil.	P,M, MD,N	VL,L,MD,N	VL,L,MD,N	1	**			
Industrial	Curb increasing costs for goods to consumers.	VU,M, I,N	VL,L,MD,N	VL,L,MD,N	1				
	Increased employment.	VU,M, MD,N	VL,L,MD,N	VL,L,MD,N	1				
Commercial	Curb increasing costs of service to consumers.	VU,M, I,N	VL,L,MD,N	VL,L,MD,N	1				
Residential	Savings to personal income over oil and gas.	VU,M, I,N	VL,L,MD,N	VL,L,MD,N	1				

**The impacts of the Ford Tech Fix Scenario and the comparisons between BOM & Tech Fix RTCs are outlined in the preceeding narrative.

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

D.15 LEGAL/INSTITUTIONAL/POLITICAL IMPACTS

Political impacts will undoubtedly occur in many of the communities where energy conversion facilities are sited in ORBES. However, these impacts will occur only in response to other earlier impacts, or the anticipation of such impacts by the local polity. Therefore, it is useful to consider political impacts as at least third-order impacts, which are likely to occur after, and in response to, such demographic, sociological, environmental, public health, and economic impacts as occur first. While noting that such political impacts are by definition tertiary, it is important to bear in mind that the community's expectation of changes in its physical environment as a result of increased energy conversion facilities in its vicinity will also create political change.

The first likely response of a community will be to demand amelioration by the responsible authorities with whom they have been accustomed to deal for other policy issues. Such officials include elective officers, such as mayors and county commissioners, as well as bureaucratic representatives of both federal and state agencies: public health officials, soil conservation agents, and environmental protection agents. If such agents prove unresponsive to the demands for change made by their constitutents, two alternative reasons may be given for such non-response: indifference on the part of the authorities or inability to act because of legal restraints.

In reaction to these two types of response, interests in the communities who wish to create change will have three approaches available to them: 1) change the responsible agents (easier to do in the case of elective officials than in the case of bureaucrats); 2) change the legislative authority of such officials; and 3) bypass both by creating new legislative authority and new agencies to deal with the problem. The latter method

is often favored when members of a community cannot know for certain whether the lack of response to their demands is caused by indifference by officials or lack of ability to respond. One method of testing this situation, however, is to take their cause to court and attempt to force action by the responsible agencies. This latter technique frequently has the effect of clarifying the law and determining whether new legislation is needed. This process is diagrammed in Figure 15.1.

It is possible to predict that increased siting of conversion facilities in ORBES will lead to increased demand for control over siting decisions. This may take the form of initially attempting to influence decisions made by the agency responsible for issuing licenses of convenience to utility companies. If little response is forthcoming from those agencies, it is reasonable to predice that court cases will be generated to force the former to allow for greater public participation in the licensing process, to respond to objections raised by public intervenors in these hearings, and generally to tighten up their process. If the persons who make these kinds of demands are not satisfied with the policymakers' response, it is likely that they will seek legislative remedies, which may range from new zoning laws at the local and county levels which might prove more responsive to local demands, to new state laws and even new federal legislation to control land-use planning.

Demographic changes in the community will doubtless lead to considerable change in the political/legal structure of the communities involved. Newcomers to the area will bring with them their own values, needs and demands for public services, which may or may not coincide with those of the longer-term residents. In addition, the simple increase in population will create strains on public services, such as education, health, crime control, environmental control, etc. These strains, and the manner in which local, state and federal officials respond to them, will create either satisfaction or demands

for structural changes in the system which is incapable of meeting these demands for public services.

Even if the political authorities are successful in meeting most new and changed demands, it is likely that the simple shift in demography and sociological balance in the community may bring about substantial political changes. These will range all the way from shifts in partisan balance in the community to changes in structures of government. One such structural change might be a shift from city councils/mayors to city managers, which often accompanies urbanization. The composition of all elective boards may be expected to shift, depending on the relative numbers of the newcomers who enter the community. In addition, the relative strengths of different institutions (county boards or commissions, school boards, sanitary boards, municipal governments, etc.) may be expected to shift also, depending on these bodies' relative responsiveness to demands made by the new political configuration in the community.

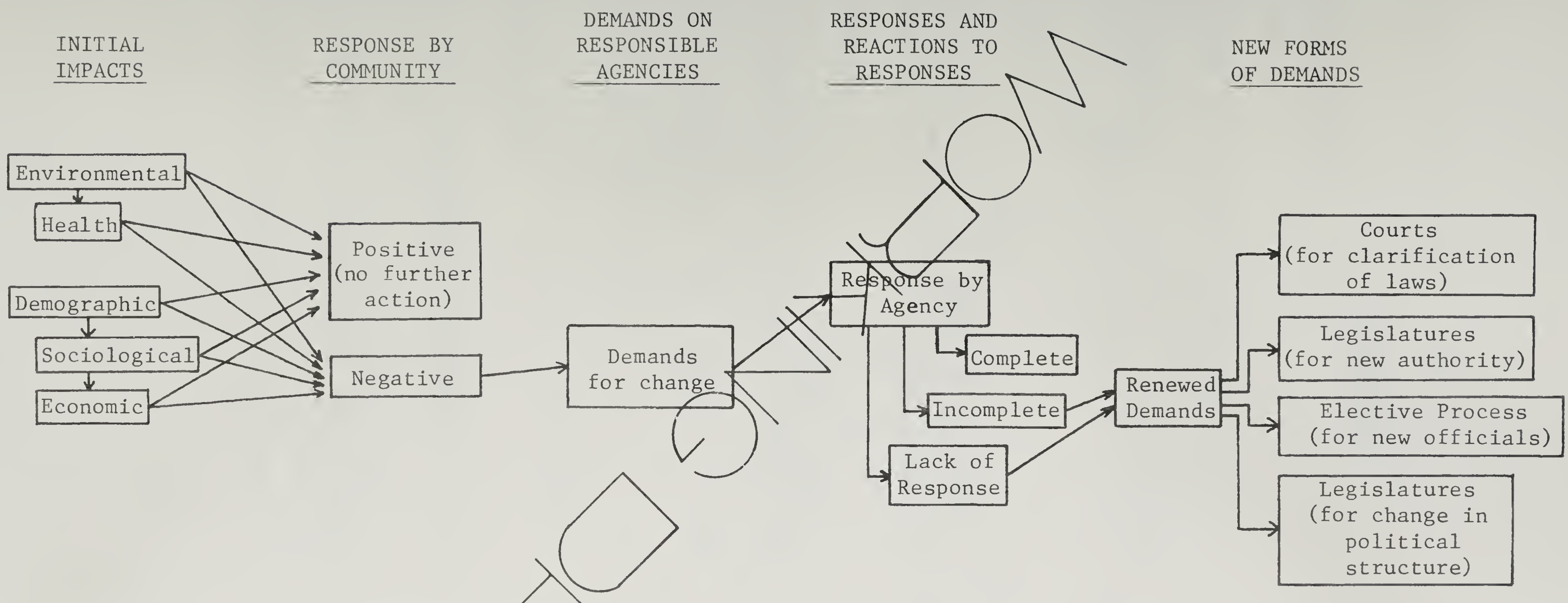


FIGURE D.15-1

LEGAL/INSTITUTIONAL/POLITICAL IMPACT PROCESS

REFERENCES

Government Documents

Laws, Federal

Atomic Energy Act of 1954 42 USC 2011
Federal Power Act 16 USC 791 et seq
Rivers and Harbors Act of 1899 US 33 USC 401 et seq
National Environmental Policy Act 42 USC 4321-4347
Federal Water Pollution Control Act 42 USC 1251 et seq
Clean Air Act 42 USC 1857 et seq

Laws, Illinois

Public Utilities Act of 1921, as amended IL Revised Statutes Ch 111-2/3
Electric Supplier Act IRS Ch 111-2/3 Sec 201
Illinois Environmental Protection Act of 1970 IRS Ch 111-1/2 Sec 100 et seq
Surface-Mined Land Reclamation and Conservation Act IRS

Laws, Kentucky

Public Utilities Act, Kentucky Revised Statutes Ch 278
Natural Resources and Environmental Protection Act KRS Ch 224
Air Pollution Control KRS Ch 77
Water Pollution Control KRS Ch 151
Radioactive Materials Act KRS Ch 152
Area Planning Commissions KRS Ch 147
Planning and Zoning Law KRS Ch 100
Strip Mining Law KRS 351-352

Council on Environmental Quality Annual Report 1-7, Washington, DC GPO 1970-76

Public Policy Books

James E. Anderson, Public Policy Making New York: Praeger, 1975.
Thomas R. Dye, Understanding Public Policy Englewood Cliffs, NJ: Prentice-Hall, 1972.
Alain C. Enthoven and A. Myrick Freeman III, Pollution, Resources and the Environment New York: W. W. Norton, 1973.
Richard I, Hofferbert, The Study of Public Policy New York: Bobbs-Merrill, 1974.
L. L. Wade and R. L. Curry, A Logic of Public Policy Belmont, CA: Wadsworth, 1970.
David Howard Davis, Energy Politics New York: St. Martin's Press, 1974.

D.16 PUBLIC HEALTH IMPACTS

Before proceeding, it might be well to define public health, as the term will be used in this study. Webster defines health, in part, as:

1. "the condition of being sound in body, mind, or soul; freedom from physical disease or pain."

2. "flourishing condition; well-being."

Well-being, in turn, is defined as "the state of being happy, healthy, or prosperous."

During the past century, great "public health" progress has been made as many infectious diseases have been brought under control. Modern public health continues to emphasize "freedom from physical disease" but is not exclusively concerned merely with reducing physical illness and postponing death. The condition of the mind and terms such as "flourishing," "happy," and even "prosperous" are now receiving increasing attention in public health education and practice.

Prosperity has been a societal goal and economic development is the means. Both are now seen as prime aspects of public health — beneficial as well as detrimental. These broader definitions which might collectively be termed "health and well-being" seem to provide the framework for the most appropriate meaningful "health" input into this energy study.

Energy transformation and utilization processes almost always generate, directly and indirectly, very significant and very complex health and well-being impacts. These impacts can affect both energy-related occupations and more general populations. Affected workers and populations can be located nearby or remote from the electric power facilities.

First of all, there are numerous relatively obvious occupational and environmental hazards associated with energy development. Several categories

are described in qualitative fashion in Table D.16-1. The most significant hazards involve mining, air pollution, and nuclear accidents, and might be termed first order impacts —that is, those directly associated with the production of electric power.

Perhaps as significant, however, are the higher-order effects of electricity production. These health and well-being ramifications might be categorized into three broad areas:

1. Living standards and other national goals. When involved in the details of energy planning and assessment, one tends to forget that energy growth is basically directed toward maintaining and improving living standards and toward related national goals such as defense. If the benefits don't exceed the environmental and other health hazards, the energy projects shouldn't be undertaken.

2. Diseases of poverty. In some areas of the world, energy development projects can have great merit, even when accompanied by extremely serious environmental and occupational hazards. Higher levels of energy production and associated economic development are essential to provide food, water, housing, clothing, and employment for growing populations. Without these basics, there is no public health. Populations must be supplied with these essentials if they are to survive long enough to be subjected to the sophisticated diseases such as those associated with ambient air pollution or with long-term occupational exposures to trace metals and organics.

   There are pockets of subsistence-level poverty in the USA and possibly some within the ORBES Region. Careful energy planning with accompanying appropriate economic development could do much to improve the health and well-being of the subsistence-level inhabitants.

   It is much more likely that within the ORBES Region there are considerable areas suffering from unemployment and underemployment, but above the subsistence level. Research at the John Hopkins School of Public Health (1) has begun to quantify the health implications of reduced employment. Increased levels of alcoholism, drug addiction, suicide, mental illness, crime (including homicide), mortality, cardiovascular and renal disease were all found to correlate directly with increased unemployment. Higher levels of energy production and associated economic development can be beneficial.

   However, these benefits can have deleterious environmental and occupational side effects. One can visualize a very high level of economic development where the adverse effects of further development could outweigh the benefits.

3. Diseases of affluence. Environmental degradation and occupational hazards are not the only deleterious health aspects which could be associated with energy growth. Accompanying these first-order direct impacts are higher order ramifications associated with plentiful, low-priced (relative to income) energy supplies. Some of these energy resources are eventually utilized for labor-saving devices and for production of high quality food (in some respects at least). Thus, at the high end of the economic spectrum, public health becomes concerned with diseases associated with an affluent sedentary life style and with obesity. Heart disease is but one example.

Some observers have noted that the diseases of poverty and affluence are similar: the stress, at both ends of the economic spectrum, can lead to alcoholism, heart failure, and other causes of premature mortality.

Energy growth, then, affects the health of at least three groups:

1. Those directly involved in energy-related occupations.
2. Local populations receiving direct environmental impacts and less-direct health impacts associated with economic growth (either positive or negative).
3. Remote populations receiving indirect economic-related health impacts associated with import of power from the Ohio River Basin.

Each should be included in the ORBES assessment. Interesting questions of equity arise if the impacts on the local population (item 2) are largely negative, while remote populations (item 3) enjoy the more beneficial impacts.

All the foregoing indicates that while there are some direct first-order adverse health effects associated with energy development, the mixture of higher-order effects complicates the situation. Additional complexities exist because most of the energy-related environmental and occupational hazards can be removed, reduced, or ameliorated —at a cost. How much expense is justified for a given hazard in a given situation?

Clearly, within a region, there are optimal levels of energy development and of hazard control, and in seeking out the optimums, all health

(and well-being) aspects must be integrated into the decision-making process. For such decision making, the health information is usually less than satisfactory, being qualitative or uncertain and not easily compared with the other decision-making inputs. Note, for example, that the qualitative information in Table D.16-1 precludes meaningful comparison from a health standpoint, of the 80-20 and the 50-50 scenarios.

The decision makers confronted by such situations seem to fall into two categories: At one end are those that consider "health" to be sacred, and feel that any adverse health effect, no matter how minor, is enough to halt any project. At the other extreme are the "quantitative objective" decision makers; they tend to totally ignore all qualitative health information because it can't be included in an "objective" cost-benefit analysis.

From society's standpoint, neither extreme is very satisfying. Public health professionals should be even less satisfied as their information tends either to be misused, or not used at all. The answer is to provide health information in a form which is not only quantitative, but directly comparable to other inputs in the decision-making analysis.

Policymakers are beginning to insist on improved quantification, wherein trade-offs between diverse impacts can be made in a straightforward manner.* Government agencies and private foundations are supporting related research throughout the country, and considerable progress is being made. Many of the results are directly applicable to the health-economic trade-offs so apparent in ORBES.

---

*In Illinois, for example, consideration of proposed environmental regulations must include an economic impact statement, and a state-sponsored Decision Analysis Task Force comprised of economics, engineering, management, and public health academicians (including a member of the ORBES project), has been created to assist in the preparation and interpretation of these comprehensive statements.

Questions of risk and uncertainity complicate efforts to quantify first- and higher-order health and well-being effects. The work "risk" itself is used in several different ways in health impact analyses; however, all are directed toward the idea of some <u>adverse</u> effect which <u>might</u> occur. They include:

1. Risk for a future effect, possibly associated with a pollutant, of which we are presently unaware, or for which a toxic effect is presently unrecognized. For example, in Japan, the very serious health effects of cadmium and mercury in water and fish became apparent 20-30 years after the pollution discharges began, long after irreversible health effects had done their damage.

2. Risk involving a presently recognized pollutant —which only affects certain (usually small) segments of the population (sometimes not defined). For example, some non-smokers acquire lung cancer; smokers have a higher probability of acquiring the disease; smoking asbestos workers have yet a higher probability of contracting lung cancer. The adverse effects of smoking and airborne asbestos are recognized; the relative risk to various populations with various exposures is partially defined. However, much uncertainity remains as to whether a given individual will ever get lung cancer.

3. Risk associated with the possibility of a future accident, such as a meltdown in a nuclear power reactor or of a mine fire or cave-in. For such situations, there is uncertainty with regard to occurence, severity, and number of people affected.

The complexities of these kinds of risk analysis are formidable, but not overwhelming. Semi-quantitative analysis of a diversity of health and economic impacts is possible now with applied probability and statistics. One meaningful approach is to compare energy risks with those which we readily accept, such as those involving air and automobile travel. For such travel, the risk-takers apparently feel that the benefits outweigh the risks. Note that such risk taking is voluntary, while that associated with invisible pollution emissions from a fossil fuel power plant is less so. The differentiation is important and should comprise a basic consideration within risk analysis.

Even highly subjective considerations can be ranked using Delphi and

other techniques. Incomplete information and less-than-accurate conclusions needn't be misleading as long as bands of uncertainty are clearly defined.

Energy-related decision-making cannot be postponed until every health and economic detail is known with certainty. Meaningful integrated assessments can proceed despite uncertainty. For the future, the opportunity exists to integrate health and well-being aspects much more directly into ORBES.

For the ORBES area, there is one overriding policy issue: How can the probabilities be improved so that for each energy development project, the net effect on health and well-being will be positive? Note that from a health and well-being standpoint, the extent of energy development (BOM versus Tech Fix) is probably more significant than the question of means (80-20 versus 50-50, 100% coal, or 100% nuclear).

Tools and data are available to quantify many of the impacts enumerated in Table D.16.1 and further to relate them to higher-order positive and negative health and well-being aspects of energy development. ORBES presents the health specialists, in close cooperation with the other ORBES investigators, with the opportunity to build and enlarge upon an ongoing long-range mission: the quantification of health effects information and the integration of these data into the policy-making process.

A step-by-step program is planned, utilizing both personnel and other resources so that short-term results will be produced, whether or not all long-range goals are realized within the time span of the ORBES project.

Work Plan

The recently enlarged ORBES health team will undertake an intensive effort during the next three months. High priority will initially be placed on quantifying first-order occupational and pollution effects

affecting employees and local residents. Several health yardsticks will be utilized and presented, including life shortening, increased morbidity, increased mortality, lost time and monetization.

Although not emphasized initially, our interest in higher-order economics-related health effects will continue, and pertinent literature will be collected for possible application during later stages of the ORBES project.

Desirable Input Information

Our current efforts are directed at relating, in a generalized fashion, adverse health effects to pollutant levels, accident probabilities, and other risks. These relationships will be applied to ORBES specifics:

1. Employment levels for each occupation involved in the energy supply system will be required.

2. The emphasis is on air pollutants, since existing water treatment processes should be able to continue to provide drinking water of adequate quality. Needed are annual average levels of a variety of air pollutants. Peak concentrations may also be utilized, but if necessary, these can be estimated using probabilistic techniques. Pollutants of interest include the particulate matter, sulfur dioxide, and nitrogen oxides generated by combustion power plants.

3. Particularly challenging will be prediction of the atmospheric transformations. For example, a variety of sulfates are considered to be more toxic than their sulfur dioxide precursor. And the river-orientation of ORBES power plants, size of the region, and prevailing wind direction seem to encourage sulfate formation and deposition within the region.

4. The contribution of combustion-derived nitrogen oxides to photochemical oxidant synthesis may also be significant. On a mass basis, oxidant is the most toxic (and least understood) of the six pollutants for which EPA has set ambient standards. Combustion contributes only one of the precursors.

5. Coal conversion facilities generate additional, ill-defined, and possibly very toxic organic compounds. Efforts might be made to characterize the pollution and health hazards associated with the relatively small number of coal conversion plants expected in ORBES by 2000.

6. If energy growth causes increased traffic and congestion, the impacts associated with increased levels of carbon monoxide and hydrocarbons should be considered.

7. The higher-order effects of air pollution associated with increased industrialization might also be considered.

8. Nuclear power presents a different problem, wherein routine emissions are under very high control and close scrutiny. The health concern here is the high levels of radioactivity which might be associated with non-routine situations.

9. Population patterns in proximity of energy facilities will be required.

10. Base case information of all kinds would be useful in defining the incremental impact of energy growth: economic status, health status, and pollution levels.

REFERENCES

1. Brenner, H., Estimating the Social Costs of National Economic Policy: Implications for Mental and Physical Health and Criminal Agression. Prepared for the Joint Economic Committee, Congress of the United States, October 1976.

2. Eisenbud, M., "Health Hazards from Radioactive Emissions," in Energy, the Environment, and Human Health, edited by Asher J. Finkel, A.M.A. Congress on Environmental Health Publishing Sciences Group, Inc., Acton, Massachusetts, 1974.

3. Finkel, A. J. (ed.), Energy, the Environment and Human Health, A.M.A. Congress on Environmental Health Publishing Sciences Group, Inc., Acton, Massachusetts, 1974.

4. Goldsmith, J. R., "Health Hazards from Power Plant Emissions," in Energy, the Environment and Human Health, edited by Asher J. Finkel, A.M.A. Congress on Environmental Health Publishing Sciences Group, Inc., Acton, Massachusetts, 1974.

5. Hoglund, B. M. and J. G. Asbury, Potential Sites for Coal Conversion Facilities in Illinois, Illinois Institute for Environmental Quality, Document No. 74-60, Chicago, Illinois, 1974.

6. Lave, L. B. and L. C. Freeburg, "Health Costs to the Consumer per Megawatt-Hour of Electricity," in Energy, the Environment and Human Health, edited by Asher J. Finkel, A.M.A. Congress on Environmental Health Publishing Sciences Group, Inc., Acton, Massachusetts, 1974.

7. Lainhart, W. S. and W. K. C. Morgan, "Extent and Distribution of Respiratory Effects" in Pulmonary Reactions to Coal Dust, edited by Marcus M. Key, Lorin E. Kerr, and Merle Bundy. Academic Press, New York, 1971.

8. Morris, P. A., "Power Plant Reactor Safety and Risk Appraisal," in Energy, the Environment and Human Health, edited by Asher J. Finkel, A.M.A. Congress on Environmental Health Publishing Sciences Group, Inc., Acton, Massachusetts, 1974.

9. Shy, C. M., V. Hasselblad, L. T. Heiderscheit and A. A. Cohen, "Environmental Factors in Bronchial Asthma," in Environmental Factors in Respiratory Disease, edited by Douglas H. K. Lee. Academic Press, New York, 1972.

10. Schlick, P. and L. Fannick, "Coal in the United States," in Pulmonary Reactions to Coal Dust, edited by Marcus M. Key, Lorin E. Kerr, and Merle Bundy. Academic Press, New York, 1971.

11. U.S. Environmental Protection Agency, Analysis of the Uranium Fuel Cycle, Part I: Fuel Supply, EPA-52019-73-003, October 1973.

12. U.S. Environmental Protection Agency, Analysis of the Uranium Fuel Cycle, Part II: Nuclear Power Reactors, EPA-52019-72-003-C.

13. Wadden, R. A., "Environmental Health Implications of Coal Conversion Processes," Proceedings, Second Inter-University Energy Conference, Constraints on Coal Utilization, May 1975.

14. Wilson, R. and W. J. Jones, Energy, Ecology and the Environment, New York: Academic Press, 1974.

15. Wyatt, J. P., "Environmental Factors in Chronic Lung Disease," in Environmental Factors in Respiratory Disease, edited by Douglas H. K. Lee, Academic Press, New York, 1972.

KEY

PARTIES AT INTEREST

1. Interest groups: Environmental
2. Interest groups: Other
3. Employees
4. Labor unions
5. Population: Local
6. Population: Remote
7. Insurance companies: Life and Health

11. Industry: Mining
12. Industry: Utility
13. Industry: Processing
14. Industry: Reprocessing
15. Industry: Rail
16. Industry: Barge
17. Industry: Highway (Trucking)

POTENTIALLY RESPONSIVE AGENCIES

Federal

1. Council on Environmental Quality (CEQ)
2. Department of Commerce (DOC)
3. Department of Transportation (DOT)
4. Environmental Protection Agency (EPA)
5. Federal Energy Administration (FEA)
6. Federal Power Commission (FPC)
7. Interstate Commerce Commission (ICC)
8. Nuclear Regulatory Commission (NRC)
9. Occupational Safety and Health Administration (OSHA)
10. Bureau of Mines (BOM)

State and Local

20. State Departments of Commerce
21. State Departments of Transportation
22. State Environmental Agencies
23. State Health Departments
24. State Labor Departments

30. Municipal and County Governmental Authorities

D.16-1

TABLE A - IMPACTS ANTICIPATED FROM COAL- AND NUCLEAR-RELATED ENERGY FUNCTIONS: Public Health - 1

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
EXTRACTION Surface Coal	Mortality & morbidity increase due to increased numbers of on-the-job accidents and slightly increased lung disease cases	AC,(S,M,L),I,LO	AC,(S,M,L),I,LO	AC,(S,M,L),I,LO	1	AC,(S,M,L),I,LO	N	3	BOM
Nuclear	Not practiced on large scale	VU	VU	VU	2	N	VU	4	BOM
Underground Coal	Mortality & morbidity increase due to increased numbers of mining accidents & increased lung disease cases	AC,(S,M,L),MD,LO	AC,(S,M,L),MD,LO	AC,(S,M,L),MD,LO	1	AC,(S,M,L),MD,LO	N	3	BOM
Nuclear	Mortality & morbidity increase due to increasing numbers of cancers (particularly lung cancer) and due to increasing numbers of mining accidents	VL,(S,L),(MD,SV),LO	VL,(S,L),(MD,SV),LO	VL,(S,L),(MD,SV),LO	1	N	VL,(S,L),(MD,SV),LO	3	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant; N-not applicable.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - PUBLIC HEALTH - 2

Function	Impact	Parties at Interest	Character-ization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
EXTRACTION Surface Coal	Mortality & morbidity increase	3,4,7,11	-,o,+,o	Dangerous working conditions	Invest in order to improve equipment; strike; press for regulation enforcement, new regulations	9,10,23,24,30	Technology improvement; improved safety practices; existing regulations enforced
Nuclear	Not practiced on large scale	N				As above	
Underground Coal	Mortality & morbidity increase	3,4,7,11	-,o,+,o	As above	As above	As above	
Nuclear	Mortality & morbidity increase	As above	As above	As above	As above	8,9,10,23,24, 30	Improved enforcement of regulations

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant; N-not applicable.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - PUBLIC HEALTH - 3

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
PROCESSING Nuclear	Mortality & morbidity increase due to increasing numbers of cancers resulting from on-the-job exposure & increasing exposure for population in the vicinity of processing. Also note accidents causing injury & death. (mostly affecting workers).	VL,L, (M,SV), LO	VL,L,(M,SV), LO	VL,L(M,SV),LO	2	N	N,(S,M,L),MD, LO	4	BOM
Coal Conversion	Mortality & morbidity increase due to an increase in carcinogenic & toxic materials in air	P,(M,L), MD,LO	P,(M,L),MD,LO	P,(M,L),MD,LO	2	P(S,M,L),I, LO	N	4	BOM

D.16-15

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant; N-not applicable.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - PUBLIC HEALTH - 4

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
PROCESSING Nuclear	Mortality & morbidity	1,2,3,4,5, 7,13	-,-,-,o,-, +,+	Dangerous work-conditions	Invest in order to improve equipment; strike; press for regulation enforcement, pass new regulations	4,8,9,10, 22,23,24,30.	Technology improvement; improved safety practices; existing regulations enforced
Coal Conversion	Mortality & morbidity increase	1,2,3,4,5, 7,13	-,-,-,o,-, +,+		Invest in more research; invest in better technology;strike	4,9,10,22, 23,24,30	Improved technology and use of technology

D.16-16

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

TABLE A - PUBLIC HEALTH - 5

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
CONVERSION Electrical Generation Coal	Mortality & morbidity increase due to increased number of bronchitis & other lung diseases, explosions & other mishaps	P,(S,M,L),MD, LO	P,(S,M,L),MD, LO	P,(S,M,L),MD, LO	Not clear	P,(S,M,L),I, LO	N	Not clear	BOM
Nuclear	Increased mortality & morbidity due to increased number of cancers & increased risk of sabotage. Accidents. Also, note possibility of sabotage or accident (e.g., loss of coolant) causing major explosion	AC,(S,L),(MD,SV), (LO,G) (Prob. 1/100 million to 1/10,000 depending on whose estimate you use	AC,(S,L),(MD, SV),(LO,G)	AC,(S,L),(MD, SV),(LO,G)	Not clear	N	P,(S,M,L),I,LO	Not clear	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant; N-not applicable.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - PUBLIC HEALTH - 6

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
CONVERSION Electrical Generation Coal	Mortality & morbidity increase	1,2,3,4,5, 7,12	-,-,-,o,-, +,+	Dangerous working conditions	Invest in order to improve equipment; strike; press for regulation enforcement, pass new regulations	4,8,9,10,22, 23,24,30	Technology improvement; improved safety practices; existing regulations enforced
Nuclear	Mortality & morbidity increase	1,2,3,4,5, 7,12	-,-,-,o,-, +,+	As above	Invest money to improve technology; pass new regulations	4,6,8,9,22, 23,24,30	Technology improvement

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd

TABLE A - PUBLIC HEALTH - 7

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
TRANSPORTATION Coal	Mortality & morbidity increase due to an increasing number of on-the-job accidents & due to increasing amounts of chronic lung disease caused by exposure during transhipment and storage	VL,(S,M,L),MD,LO	VL,(S,M,L),MD,LO	VL,(S,M,L),MD,LO	Not clear	VL,(S,M,L),MD,LO	N	Not clear	BOM
Nuclear	Increased mortality & morbidity due to increased number of cancers resulting from increasing exposure to radioactive materials. Accidents. Note also transportation--theft & sabotage.	AC,L,(MD,SV),LO	AC,L,(MD,SV),LO	AC,L,(MD,SV),LO	Not clear	N	VL,(S,M,L),MD,LO	Not clear	BOM

D.16-19

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant; N-not applicable.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - PUBLIC HEALTH - 8

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
TRANSPORTATION Coal	Mortality & morbidity increase	1,2,3,4,5,7, 15,16,17,18	-,-,-,o,-,+, +,+,+,+	On-the-job exposure to coal dust & occupational hazards	Invest in equipment improvement; strike; press for improved regulations; press for enforcement of existing regulations	3,7,9,20,21, 23,24,30	Improved equipment; improved regulations; better regulation enforcement
Nuclear	Mortality & morbidity increase	1,2,3,4,5,7, 15,16,17,18	-,-,-,o,-,+, +,+,+,+	As above	Invest in improved security; strike	3,7,8,9,20, 21,23,24,30	Improved security

D.16-20

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

TABLE A - PUBLIC HEALTH - 9

Function	Impact	1985* (BOM)	(1) 2000 BOM 80-20	(2) 2000 BOM 50-50	More severe (1) or (2)	(3) 2000 Tech Fix 100% Coal	(4) 2000 Tech Fix 100% Nuclear	More severe (3) or (4)	More severe (BOM) or (Tech Fix)
WASTE DISPOSAL									
Coal	Variety of industrial accident hazards	VL,S,I, LO	VL,S,I,LO	VL,S,I,LO	2	P,S,I,LO	N	4	BOM
Nuclear	Increased mortality & morbidity due to increased number of cancers resulting from increasing exposure to radioactive materials. Accidents. (Note: necessary if considering waste disposal for periods of around 2000 yrs) Protection against earthquake & possibility of sabotage	AC,L, (MD,SV), (LO,G)	AC,L,(MD,SV), (LO,G)	AC,L,(MD,SV), (LO,G)	2	N	VL,L,MD,LO	4	BOM

LEGEND: PROBABILITY OF OCCURRENCE: AC-almost certain; VL-very likely; P-as probable as not; VU-very unlikely; AI-almost impossible.
DURATION: S-short term; M-medium term; L-long term.
INTENSITY: SV-severe; MD-moderately intense; I-insignificant; N-not applicable.
GEOGRAPHICAL SCALE: LO-local; MC-multicounty; SR-subregional; ST-state; R-ORBES region; N-national; G-global.

*An insignificant change is expected under the Tech Fix Scenario to the year 1985.

3/3/77 bd

TABLE B - PUBLIC HEALTH - 10

Function	Impact	Parties at Interest	Characterization of Impact on Parties	Issues or Problems	Policy Options	Potentially Responsive Agencies	Resulting Technological and Societal Accommodations
WASTE DISPOSAL							
Coal	Industrial accident hazards	1,2,3,4, 12,14	-,-,-,o, -,+	On-the-job accidents	Invest in equipment improvement; enforce regulations	4,9,22,23, 24,30	Improved equipment; better regulation enforcement
Nuclear	Mortality & morbidity increase	1,2,3,4,5,6, 7,12,14,15,17	-,-,-,o,-,-, +,-,+,+,+	On-the-job exposure	Invest in improved security	4,8,9,22, 23,24,30	Improved security

LEGEND: SEVERITY OF IMPACT: SV-severe; M-moderate; I-insignificant.
EFFECT ON PARTY: +-favorable; --unfavorable; o-neutral; ?-unknown.

3/3/77 bd.

E. SUMMARY AND FUTURE WORK

E.0 SUMMARY AND FUTURE WORK

E.1 COMPARISON OF IMPACTS OF FOUR ENERGY DEMAND SCENARIOS AT THE YEAR 2000

The numbers of power generation facilities as well as their geographical distribution are significantly greater under the BOM scenarios. Consequently, the aggregate regional effects of the impacts will be greater in the year 2000 for the BOM scenarios as compared to the Ford Tech Fix scenarios.

The most severe, negative impacts affect the physical-biological environment. The impacts which are restricted to local scale are associated with change in the biota (e.g., in the destruction of existing communities). The impacts which occur at local and greater geographical scale include changes in land use and associated problems, such as subsidence and acid drainage, and in air, land and water quality. These changes are also considered to have an immediate impact as the result of extraction and conversion functions.

Some impacts will have a positive impact. Population growth resulting from increased employment may create local short-term problems associated with "boom town" cycles. In the long-term, growth can result in benefits to the region and, if properly managed, at local scale as well. Other regional economic benefits are decreased reliance on petroleum as a fuel, a curb on increased prices for goods and services and increased personal savings.

Most of the significant impacts which have been identified will have long-term effects within the ORBES region, and have a high probability of occurrence. Selected biological impacts (fish kills and destruction of existing communities) are exceptions to the long-term effects; radioactive contamination and increased concentration of water pollutants because of decreased flow have lower probabilities of occurrence.

Comparison of BOM 80-20 and 50-50 Scenarios

The identifications, characterizations and evaluations of the impacts of coal- and nuclear-related energy functions across all impact categories indicate that the 80-20 fuel mix of the BOM scenario will have a more significant overall effect on the ORBES region in the year 2000 than the 50-50 fuel mix. The major reasons are the number of counties involved in conversion processes, the levels of extraction within the region, transportation requirements and the larger amounts of emission and waste products related to the 80-20 fuel mix.

Comparison of Ford Tech Fix 100% Coal and 100% Nuclear

Because of the greatly lessened projected demand by the year 2000, neither of the Ford Tech Fix scenarios will have severity of impacts as strong as the BOM scenarios. Beyond presently committed stations, there is only a limited number of stations to be added under the Ford Tech Fix. Since there is greater impact associated with a more heavily coal-fired RTC, the Ford Tech Fix 100% coal scenario will have a somewhat more severe impact than the Ford Tech Fix 100% nuclear scenario for much the same reasons that the BOM 80-20 has more impact than the BOM 50-50.

E.2 QUESTIONS RELATED TO THE BOM AND FORD TECH FIX SCENARIOS

As indicated throughout this report, especially Chapter D, the energy conversion requirements of the two BOM scenarios impose much more severe physical and environmental impacts by the year 2000 than do the two scenarios of the Ford Tech Fix. However, the limited growth and energy conservation approach of the Ford Tech Fix will produce a considerable number of impacts on the social and political system. Thus the Ford Tech Fix evaluation requires a careful analysis of both economic and public policy issues for the future.

Under the Ford Tech Fix scenarios, the nation will invest more capital funds in buildings - both residential and commercial - as a trade-off for economies in fuel costs which will be reflected much later in operating savings. The required changes in "life style" will require public acceptance of a "pay now--save later" philosophy which has not been our nation's mode of operation in the past. Also, the Ford Tech Fix requires the reversal of the present strong trend toward convenience and labor saving approaches with resulting increased energy utilization. Many questions related to economic, social and public policy issues may be posed.

1. How does the body politic propose to encourage the large and early capital investments required to produce conservation implied in the Ford Tech Fix scenario over the long-run?

2. Will the natural or (perhaps) artificial increases in energy fuel costs come soon enough to encourage or "force" the acceptance of large capital investments required in residential and commercial building costs for insulation, storm windows, heat pumps, solar augmentation of heating, etc.?

3. Can public institutions effectively provide incentives in such forms as forgivable loans, mortgage augmentation, or tax reductions or remissions to encourage individuals and corporate management to take conservation measures?

4. Are people willing to give up employment, even on a temporary basis, to keep warm when excess capacity of a given energy system is overburdened by extreme weather or fuel shortages? Who makes and enforces the appropriate regulations and controls?

5. What are the relative economic implications of the BOM and Ford Tech Fix scenarios? The very large rate of projected electrical energy use per capita in BOM dictates a strong shift to electrical power in the residential, commercial and industrial sectors by 2000. This form of energy is capital investment intensive but, by current economics, relative inexpensive in operating costs. The more modest Ford Tech Fix projections also require substantial capital investments for conservation which are not necessarily driven by nor productive of GNP growth and resulting prosperity. Will capital resources be available to implement the BOM scenario even with GNP growth or the Ford Tech Fix scenario without the corresponding GNP growth?

6. The rate-price structure of "competitive" fuels (including electricity) are partially regulated and partially free market determined. Current rate structures are inverted to be attractive to large multiple fuel users. Also some large energy users (processing and manufacturing) are scheduled on different fuels or energy sources during off peak demand. Others have been forced to convert to cleaner fuels (gas and oil) by regulations governing environmental emissions. In order to promote conservation of energy a <u>direct</u> rate-pricing structure may be necessary; i.e., the more energy used, the higher the unit cost of the energy should be! Since this is contrary to normal economic pricing standards, who will regulate and how will regulations be enforced?

The above questions are substantive and many of them will require both long-term study, debate and resolution (or compromise) more realistically suited to the Phase II aspects of the ORBES study. The answers may lie in technological innovation or the better adaptation of known technology to the problem. However, the answers will also largely be forced by public opinion including the willingness of the public to subject personal convenience to regulation and control.

E.3 FUTURE WORK

During the interim between this second preliminary report and the third (and final) report of this Task 2 mini-technology assessment effort, the Illinois team will revise and extend the material in this report to more comprehensively cover the comparative aspects of the four RTC's related to the BOM and Ford Tech Fix scenarios. Specifically a number of aspects of the physical and environmental primary impacts are being quantified to a greater degree than in this report. The resulting second and higher order impacts related to biological, economic, societal and institutional aspects of the study can be more accurately defined as to severity and time scale. Also, additional interactions between the broad range of disciplines represented on the Illinois team should develop "feed-back" information which may suggest weaknesses and/or desirable changes in the assumptions used in formulating the present RTC's related to both the BOM and Ford Tech Fix scenarios. A better set of baseline futures projected to the year 2000 would be helpful in understanding the economic, social and political implications of the RTC's now being studied. In turn, the range of public policy issues and options may suggest certain modifications in the types or the time scale of the technological innovations now being assumed.

The final report will include technology assessment for fuel conversion on a modest scale for the production of high-BTU pipeline quality synthetic gas from coal as well as low-BTU utility gas for direct use in electrical energy conversion units.

In the final analysis, the major contribution of the Task 2 (Phase I) effort will be a comprehensive but preliminary evaluation of the broad aspects

of the electrical energy-conversion and fuel-conversion related impacts for the four RTC's in question. Phase II of this continuing study is intended to provide a much more in-depth analysis. Thus, an important aspect of the final report on Task 2-Phase I effort must be to delineate the questions and problems identified by the mini-assessment process which require more detailed attention in the future Phase II study.

The schedule of activities for the Illinois team from March 15, 1977 to the end of Task 2-Phase I activities is as follows:

1. Team meeting March 21 at Chicago Circle to consider additional material beyond this second preliminary report for the Carbondale (third) public meeting.

2. Third public meeting to be held at Carbondale, Illinois on the afternoon and evening of April 4, 1977.

3. Interactive meetings between sub-groups of the Illinois team to obtain "feed-back" on physical, environmental and biological matters with economic, societal and public policy matters and vice versa.

4. Final report due in Project Office on May 15, 1977. This report, along with other Task 2 team reports, will provide the Project Office with material to perform the Task 3 evaluative report for Phase I. This evaluative report for all Phase I studies will be returned to the three Task 2 teams for review and comment. The Task 2 Illinois final report will constitute one of the appendice of the Task 3 report.

5. Illinois team meeting during the week of May 23 in preparation for the fourth public meeting in Springfield, Illinois.

6. Fourth public meeting of the Illinois team at Springfield, Illinois during the morning and afternoon of Friday, June 3, 1977. In addition to an

open meeting for the general public the Illinois team will encourage the attendance of legislators and their staffs as well as representatives of the executive branch responsible for formulating public policy regarding both energy and environmental problems.

7. Response to the Project Office on final report of Phase I.

8. Formal close of Task 2-Phase I ORBES by June 30, 1977.

APPENDIX I

SITING CONFIGURATIONS - BOM SCENARIO
WITH 80-20 AND 50-50 FUEL MIXES

BOM 80-20	COUNTIES		
STATE	Coal[a]	Nuclear[a]	Coal Gasification[b]
ILLINOIS			
	Brown (2)	Cass (2)	Perry - High Btu
	Clark (2)	Marshall (2)	St. Clair - Low Btu
	Greene (2)	Mercer (2)	
	Hamilton (2)		
	Jersey (2)		
	Lawrence (2)		
	Marshall (2)		
	Perry (1)		
	Pulaski (2)		
	Schuyler (2)		
	Scott (2)		
	Washington (2)		
	White (2)		
Total	(25)	(6)	(2)
INDIANA			
	Clark (1)	Daviess (1)	
	Crawford (1)	Fountain (1)	
	Daviess (2)	Greene (1)	
	Dearborn (2)	Harrison (1)	
	Dubois (1)	Perry (1)	
	Fountain (1)	Spencer (1)	
	Gilson (1)	Switzerland (1)	
	Greene (1)		
	Harrison (2)		
	Jackson (1)		
	Knox (1)		
	Lawrence (1)		
	Martin (1)		
	Ohio (1)		
	Perry (2)		
	Pike (1)		
	Posey (1)		
	Spencer (1)		
	Sullivan (1)		
	Switzerland (1)		
	Tippecanoe (1)		
	Vermillion (1)		
	Warren (1)		
	Warrick (1)		
Total	(27)	(7)	

[a] Numbers of 1000 MWe plant units are in parentheses.

[b] Full-scale plant with 250,000,000 cubic feet per day capacity.

Appendix I-2

SITING CONFIGURATIONS - BOM SCENARIO
WITH 80-20 AND 50-50 FUEL MIXES

BOM 80-20	COUNTIES		
STATE	Coal[a]	Nuclear[a]	Coal Gasification[b]
KENTUCKY			
	Ballard (2)	Lewis (1)	
	Bracken (2)	Russell (2)	
	Breckinridge (2)		
	Butler (1)		
	Carliste (2)		
	Gallstin (3)		
	Greenup (2)		
	Livingston (2)		
	Marshall (2)		
	Mclean (1)		
	Meade (2)		
	Owen (1)		
	Trimble (3)		
	Trigg (2)		
	Union (2)		
	Webster (2)		
Total	31	3	
OHIO			
	Athens (3)	Belmont (1)	
	Brown (3)	Brown (1)	
	Butler (3)	Gallia (1)	
	Clark (2)	Lawrence (1)	
	Clermont (3)	Meigs (1)	
	Franklin (2)	Monroe (1)	
	Gallia (3)	Morgan (1)	
	Hamilton (2)	Muskingum (1)	
	Lawrence (3)	Pike (1)	
	Mahoning (3)	Ross (1)	
	Meigs (3)	Scioto (1)	
	Miami (2)	Washington (1)	
	Montgomery (2)		
	Morgan (3)		
	Pickaway (2)		
	Ross (3)		
	Warren (3)		
	Washington (3)		
Total	48	12	

[a]Numbers of 1000 MWe plant units are in parentheses.

[b]Full-scale plant with 250,000,000 cubic feet per day capacity.

Appendix I-3

SITING CONFIGURATIONS - BOM SCENARIO
WITH 80-20 AND 50-50 FUEL MIXES

BOM 50-50 / STATE	COUNTIES: Coal[a]		Nuclear[a]		Coal Gasification
ILLINOIS	Brown	(2)	Cass	(2)	Perry - High Btu
	Clark	(2)	Greene	(2)	St. Clair - Low Btu
	Greene	(2)	Hancock	(2)	
	Hamilton	(2)	Henderson	(2)	
	Jersey	(2)	Iroquois	(1)	
	Lawrence	(2)	Livingston	(2)	
	Pulaski	(2)	Marshall	(2)	
	Washington	(2)	Mercer	(2)	
Total		16		15	2
INDIANA	Clark	(1)	Clark	(1)	
	Crawford	(1)	Crawford	(1)	
	Daviess	(1)	Daviess	(1)	
	Fountain	(1)	Dearborn	(1)	
	Gibson	(1)	Fountain	(1)	
	Harrison	(2)	Greene	(1)	
	Martin	(1)	Harrison	(2)	
	Perry	(2)	Jefferson	(1)	
	Pike	(1)	Ohio	(1)	
	Posey	(1)	Perry	(2)	
	Spencer	(1)	Spencer	(1)	
	Sullivan	(1)	Sullivan	(1)	
	Switzerland	(1)	Switzerland	(1)	
	Vermillion	(1)	Tippecanoe	(1)	
	Warren	(1)	Vermillion	(1)	
Total		17		17	
KENTUCKY	Breckinridge	(2)	Bracken	(3)	
	Carliste	(2)	Greenup	(2)	
	Livingston	(2)	Lewis	(3)	
	Marshall	(2)	Mason	(3)	
	Meade	(2)	Russell	(3)	
	Owen	(1)	Trimble	(3)	
	Trigg	(2)			
	Union	(2)			
	Webster	(2)			
Total		17		17	

[a]Numbers of 1000 MWe plant units are in parentheses.

[b] Full-scale plant with 250,000,000 cubic feet per day capacity.

Appendix I-4

SITING CONFIGURATIONS - BOM SCENARIO
WITH 80-20 AND 50-50 FUEL MIXES

BOM 50-50	COUNTIES				
STATE	Coal[a]		Nuclear[a]		Coal Gasification
OHIO					
	Athens	(2)	Belmont	(4)	
	Brown	(2)	Brown	(4)	
	Butler	(2)	Gallia	(4)	
	Clark	(2)	Lawrence	(2)	
	Clermont	(2)	Meigs	(4)	
	Franklin	(2)	Monroe	(4)	
	Gallia	(1)	Morgan	(2)	
	Hamilton	(1)	Muskingum	(1)	
	Lawrence	(1)	Pike	(1)	
	Mahoning	(2)	Ross	(2)	
	Meigs	(2)	Scioto	(1)	
	Miami	(2)	Washington	(1)	
	Montgomery	(2)			
	Morgan	(2)			
	Pickaway	(1)			
	Ross	(2)			
	Washington	(2)			
Total		30		30	

[a] Numbers of 1000 MWe plant units are in parentheses.

[b] Full-scale plant with 250,000,000 cubic feet per day capacity.

APPENDIX II

ILLINOIS

Year	Name of Plant	Location	MW(E) Capacity	Type
1976	Duck Creek 1	Fulton	400	Coal
	Wallace 1 and 2	E. Peoria	42	Gas
1977	Newton 1	Newton	550	Coal
	Dallman 3	Springfield	178	Coal
1979	Havana 6	Havana	450	Coal
1981	Lakeside 1 and 2	Springfield	-25	Oil
1983	Marion 4	Williamson County	173	Coal
1985	Hutsonville 1 and 2	Hutsonville	-50	Oil
1986	Duck Creek 2	Fulton	400	Coal
	LaSalle 1	Seneca	1078	Nuclear
1987	Fossil Cap.	Unknown	20	Coal
1988	Newton 2	Newton	550	Coal
	LaSalle 2	Seneca	1078	Nuclear
	Lakeside 1 and 2	Springfield	22	Oil
	Reynolds 2	Springfield	50	Oil
1989	Clinton 1	Clinton	950	Nuclear
1990	Marion 5	Williamson County	150	Coal
1991	Duck Creek 3	Fulton	600	Coal
	Clinton 2	Clinton	950	Nuclear
1993	Newton 3	Newton	500	Coal
	Plant X#1	Unknown	600	Coal
	Factory 2	Springfield	50	Oil
	Fossil Cap.	Unknown	20	Coal

Appendix II-2

ILLINOIS

TECH FIX COAL

Year	County	MW(E) Capacity
1994	Greene	600
1997	Greene	600

TECH FIX NUCLEAR

Year	County	MW(E) Capacity
1994	Marshall	1000

INDIANA

Year	Name of Plant	Location	MW(E) Capacity	Type
1976	Gibson 1	Gibson County	650	Coal
	Schahfer 14	Jasper County	477	Coal
1977	Petersburg 3	Pike County	532	Coal
1981	Gibson 2	Gibson County	668	Coal
	Rensselaer 4	Jasper County	-1	Oil
1984	Brown 1	Posey County	265	Coal
1985	Schahfer 15	Jasper County	527	Coal
1986	Gibson 3	Gibson County	668	Coal
1988	Merom 1	Sullivan County	490	Coal
1989	Merom 2	Sullivan County	490	Coal
1990	Petersburg 4	Pike County	532	Coal
	Marble Hill 1	Jefferson County	1130	Nuclear
	Rensselaer 13	Jasper County	5.5	Oil (Gas)
1992	Brown 2	Posey County	350	Coal
1993	Undesignated		650	Coal
1994	White Water Valley	Wayne County	100	Coal
	Marble Hill 2	Jefferson County	1130	Nuclear

INDIANA

TECH FIX COAL

Year	County	MW(E) Capacity
1995	Warren	600
1996	Pike	600
1997	Crawford	600
1998	Fountain	600
2000	Posey	600

TECH FIX NUCLEAR

Year	County	MW(E) Capacity
1995	Perry	1000
1997	Daviess	1000
1999	Harrison	1000

KENTUCKY

Year	Name of Plant	Location	MW(E) Capacity	Type
1976	Spurlock 1	Winchester	300	Coal
	Reid 1	Sebree	65	Oil
1977	Ghent 2	Ghent	500	Coal
	Mill Creek 3	Louisville	425	Coal
1979	Reid 2	Sebree	200	Coal
	Paddys Run 2	Louisville	-29	Coal
	Paddys Run 1	Louisville	-30	Coal
1981	Paddys Run 3	Louisville	-64	Coal
	Paddys Run 4	Louisville	-66	Coal
1982	Mill Creek 4	Louisville	495	Coal
1983	Paddys Run 5	Louisville	-71	Coal
1984	Paddys Run 6	Louisville	-68	Coal
1985	Cane Run 1	Louisville	-111	Coal
1986	Spurlock 2	Winchester	500	Coal
1987	KU Unit 1	Undesignated	500	Coal
1989	East Bend 2	Rabbit Hash	669	Coal
	Trimble County 1	Trimble County	495	Coal
1990	KU Unit 2	Undesignated	500	Coal
	Undesignated	--	65	Oil
1992	EK Unit	Undesignated	500	Coal
	East Bend 3	Rabbit Hash	800	Coal
	Reid 3	Sebree	200	Coal
1993	East Bend 1	Rabbit Hash	669	Coal
	Trimble County 2	Trimble County	495	Coal
1994	KU Unit 3	Undesignated	650	Coal

KENTUCKY

TECH FIX COAL

Year	County	MW(E) Capacity
1995	Marshall	600
	Trimble	600
1996	Nicholas	600
	Livingston	600
1998	Union	600
1999	Union	600
	Henderson	600
2000	Franklin	600

TECH FIX NUCLEAR

Year	County	MW(E) Capacity
1995	Mason	1000
1997	Russell	1000
2000	Mason	1000

OHIO

Year	Name of Plant	Location	MW(E) Capacity	Type
1976	Conesville 5	Conesville	375	Coal
	Martins Ferry	Martins Ferry	-2	Oil
1977	Cardinal 3	Brilliant	615	Coal
	Racine	Racine	40	Hydro
	West End 2, 5 and 6	Cincinnati	-111	Gas
1978	West End 1, 3 and 4	Cincinnati	-108	Gas
1979	Miami Fort 3 and 4	Hamilton	-130	Unknown
1980	Miami Fort	Hamilton	557	Coal
	Picway 3 and 4	Columbus	-64	Coal
	Columbus	Columbus	-53	Unknown
1983	Conesville 6	Conesville	375	Coal
1987	Killen 2	Wrightville	661	Coal
	Zimmer 1	Clermont County	878	Nuclear
1988	Poston 5		375	Coal
1991	Killen 1	Wrightville	661	Coal
	Poston 6		375	Coal
1992	Cardinal 4	Brilliant	615	Coal

OHIO

TECH FIX COAL

Year	County	MW(E) Capacity
1995	Miami	600
	Mahoning	600
1996	Franklin	600
1997	Athens	600
	Meigs	600
	Butler	600
1998	Clermont	600
	Morgan	600
	Clark	600
1999	Ross	600
	Montgomery	600
	Warren	600

TECH FIX NUCLEAR

Year	County	MW(E) Capacity
1995	Belmont	1000
1996	Brown	1000
	Gallia	1000
1997	Muskingum	1000
1998	Monroe	1000
	Lawrence	1000
1999	Meigs	1000
2000	Morgan	1000
	Washington	1000